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(54) **CONNECTION MECHANISM FOR ULTRASOUND-VIBRATION GENERATING/TRANSMITTING UNIT, AND PRODUCTION METHOD FOR ULTRASOUND-VIBRATION GENERATING/TRANSMITTING UNIT**

(57) A connection mechanism (300) for an ultrasonic-vibration generating/transmitting unit (200) is provided in each of parts constituting the ultrasonic-vibration generating/transmitting unit (200) which generates and transmits ultrasonic vibration, the connection mechanism connecting the parts to each other to form the ultrasonic-vibration generating/transmitting unit (200).

When an one end portion (41a) is inserted into a cylinder member (301) from a cylinder-side one end portion (341a) and when the other end portion (51a) is in-

serted into the cylinder member (301) from a cylinder-side other end portion (351a) so that the other connection portion (51g) is connected to a cylinder-side connection portion (351g), a held portion (41c) is held by an end face (511a) of the other end portion (51a) and a cylinder-side protrusion portion (341c) in the axial direction of the cylinder member (301), whereby the one end portion (41a) and the other end portion (51a) are connected to each other.

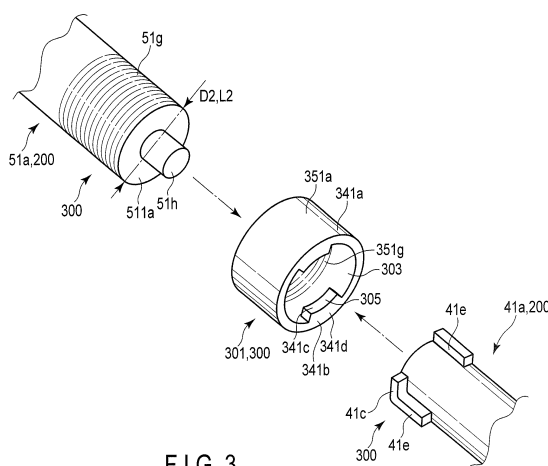


FIG. 3

Description

Citation List

Technical Field

Patent Literature

[0001] The present invention relates to a connection mechanism for an ultrasonic-vibration generating/transmitting unit which generates and transmits ultrasonic vibration, and a production method for the ultrasonic-vibration generating/transmitting unit.

5 **[0007]** Patent Literature 1: Jpn. Pat. Appln. KOKAI Publication No. 8-224252

Summary of Invention

Background Art

10 Technical Problem

[0002] In general, an ultrasonic treatment apparatus includes an ultrasonic vibrator which generates ultrasonic vibration, a probe which is connected to the ultrasonic vibrator and which is a transmitting member to transmit the ultrasonic vibration generated in the ultrasonic vibrator, and a treatment portion which is provided at the end of the probe and which treats, for example, a treatment part of a living tissue with the ultrasonic vibration transmitted by the probe. The ultrasonic vibrator and the probe serve as an ultrasonic-vibration generating/transmitting unit which generates ultrasonic vibration and which transmits the ultrasonic vibration. The ultrasonic vibrator represents one of parts constituting the ultrasonic-vibration generating/transmitting unit, and the probe represents the other part.

[0008] According to Patent Literature 1, when the joint portion and the chip portion are connected to each other, the joint surface between the joint portion and the chip portion, and the joint surface between the chip portion and the fixing thread need to be firmly press-connected. Therefore, the fixing thread needs to be more toothed to the connection thread of the joint portion. In other words, the fixing thread needs to be rotated relative to the connection thread of the joint portion more than once. On the other hand, when the joint portion and the chip portion are disconnected from each other, the fixing thread needs to be separated from the connection thread. Therefore, if the connection thread of the joint portion and the fixing thread are toothed in more parts, it takes time for the fixing thread to be separated. In this way, according to Patent Literature 1, the connection operation and the disconnection operation are troublesome.

[0003] The ultrasonic vibrator and the probe need to be firmly coupled to each other so that the ultrasonic vibration generated in the ultrasonic vibrator is fully transmitted to the probe. The probe including the treatment portion that has been once used needs to be replaced with a probe including a clean treatment portion for each surgical operation. Therefore, the probe is removable from the ultrasonic vibrator unit.

[0009] In view of the above-mentioned problems, the present invention provides a connection mechanism for an ultrasonic-vibration generating/transmitting unit and a production method for the ultrasonic-vibration generating/transmitting unit which enable one of parts constituting the ultrasonic-vibration generating/transmitting unit and the other part to be connected to and disconnected from each other without any trouble.

[0004] For example, Patent Literature 1 has disclosed a surgical handpiece which is an example of the above ultrasonic treatment apparatus.

Solution to Problem

[0005] In the surgical handpiece according to Patent Literature 1, a joint portion and a chip portion are removable from each other. When the joint portion and the chip portion are connected to each other, a depression portion provided at the front end of the joint portion is first fitted to a projection provided at the rear end of the chip portion. A fixing thread is then fastened to a connection thread provided on the outer circumference of the distal end portion of the joint portion. As a result, a joint surface between the joint portion and the chip portion, and a joint surface between the chip portion and the fixing thread are firmly press-connected, and the joint portion and the chip portion are connected to each other.

40 **[0010]** An aspect of a connection mechanism for an ultrasonic-vibration generating/transmitting unit, the connection mechanism being provided in each of parts constituting the ultrasonic-vibration generating/transmitting unit which generates and transmits ultrasonic vibration, the connection mechanism connecting the parts to each other to form the ultrasonic-vibration generating/transmitting unit, the connection mechanism including one end portion representing one end portion of one of the parts; a held portion which is provided on the outer circumferential surface of the one end portion and which is provided along the circumferential direction of the one end portion; other end portion representing one end portion of the other part which is connected to the one end portion; other connection portion which is provided on the outer circumferential surface of the other end portion and which is provided over the circumference of the other end portion along the circumferential direction of the other end portion; and a cylinder member, the cylinder member in-

[0006] When the joint portion and the chip portion are disconnected from each other, the fixing thread is separated from the connection thread provided on the outer circumference of the distal end portion of the joint portion.

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cluding a cylinder-side one end portion into which the one end portion is inserted, a cylinder-side other end portion into which the other end portion is inserted, a cylinder-side protrusion portion which is provided on the inner circumferential surface of the cylinder-side one end portion and which protrudes inward from the inner circumferential surface and which is provided along the circumferential direction of the cylinder-side one end portion, and a cylinder-side connection portion which is provided on the inner circumferential surface of the cylinder-side other end portion and which is provided over the circumference of the cylinder-side other end portion along the circumferential direction of the cylinder-side other end portion, wherein when the one end portion is inserted into the cylinder member from the cylinder-side one end portion and when the other end portion is inserted into the cylinder member from the cylinder-side other end portion so that the other connection portion is connected to the cylinder-side connection portion, the held portion is held by the end face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member, whereby the one end portion and the other end portion are connected to each other.

[0011] An aspect of a production method for an ultrasonic-vibration generating/transmitting unit to connect parts constituting the ultrasonic-vibration generating/transmitting unit which generates and transmits ultrasonic vibration to form the ultrasonic-vibration generating/transmitting unit, wherein there are provided: one end portion representing one end portion of one of the parts; a held portion which is provided on the outer circumferential surface of the one end portion and which is provided along the circumferential direction of the one end portion; other end portion representing one end portion of the other part which is connected to the one end portion; other connection portion which is provided on the outer circumferential surface of the other end portion and which is provided over the circumference of the other end portion along the circumferential direction of the other end portion; and a cylinder member, the cylinder member including a cylinder-side one end portion into which the one end portion is inserted, a cylinder-side other end portion into which the other end portion is inserted, a cylinder-side protrusion portion which is provided on the inner circumferential surface of the cylinder-side one end portion and which protrudes inward from the inner circumferential surface and which is provided along the circumferential direction of the cylinder-side one end portion, and a cylinder-side connection portion which is provided on the inner circumferential surface of the cylinder-side other end portion and which is provided over the circumference of the cylinder-side other end portion along the circumferential direction of the cylinder-side other end portion, the production method including a process of connecting one of the part and the other part, the connection process including inserting one end portion into the cylinder member from the cylinder-side one end portion so that the held portion is held by the end

face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member, inserting the other end portion into the cylinder member from the cylinder-side other end portion so that the other connection portion is connected to the cylinder-side connection portion, and thereby connecting the one end portion and the other end portion to each other.

Advantageous Effects of Invention

[0012] According to the present invention, it is possible to provide a connection mechanism for an ultrasonic-vibration generating/transmitting unit and a production method for the ultrasonic-vibration generating/transmitting unit which enable one of parts constituting the ultrasonic-vibration generating/transmitting unit and the other part to be connected to and disconnected from each other without any trouble.

Brief Description of Drawings

[0013]

FIG. 1 is a schematic diagram of an ultrasonic treatment system according to a first embodiment of the present invention;

FIG. 2 is a schematic diagram showing the configuration of an ultrasonic treatment apparatus;

FIG. 3 is an exploded perspective view of an ultrasonic-vibration generating/transmitting unit and a connection mechanism;

FIG. 4A is a perspective view of one end portion of an ultrasonic vibrator;

FIG. 4B is a side view of one end portion of the ultrasonic vibrator;

FIG. 4C is a front view of one end portion of the ultrasonic vibrator;

FIG. 5A is a front view of a cylinder member viewed from a cylinder-side one end portion;

FIG. 5B is a sectional view taken along the line 5B-5B shown in FIG. 5A;

FIG. 6 is a flowchart showing a production method for the ultrasonic-vibration generating/transmitting unit according to the first embodiment;

FIG. 7A is a diagram illustrating Step 1 shown in FIG. 6;

FIG. 7B is a diagram illustrating Step 1 shown in FIG. 6;

FIG. 7C is a diagram illustrating Step 2 shown in FIG. 6;

FIG. 7D is a diagram illustrating Step 2 shown in FIG. 6;

FIG. 7E is a diagram illustrating Step 2 shown in FIG. 6;

FIG. 7F is a diagram illustrating Step 3 shown in FIG. 6;

FIG. 7G is a diagram illustrating Step 3 shown in FIG. 6;

FIG. 7H is a diagram illustrating Step 3 shown in FIG. 6;
 FIG. 7I is a diagram illustrating Step 3 shown in FIG. 6;
 FIG. 7J is a diagram illustrating Step 4 shown in FIG. 6;
 FIG. 7K is a diagram illustrating Step 4 shown in FIG. 6;
 FIG. 7L is a diagram illustrating Step 5 shown in FIG. 6;
 FIG. 7M is a diagram illustrating Step 5 shown in FIG. 6;
 FIG. 8 is a diagram illustrating a modification of one end portion of the ultrasonic vibrator;
 FIG. 9 is an exploded perspective view of an ultrasonic-vibration generating/transmitting unit and a connection mechanism according to a second embodiment;
 FIG. 10 is a flowchart showing a production method for the ultrasonic-vibration generating/transmitting unit according to the first embodiment;
 FIG. 11A is a diagram illustrating Step 11 shown in FIG. 10;
 FIG. 11B is a diagram illustrating Step 11 shown in FIG. 10;
 FIG. 11C is a diagram illustrating Step 12 shown in FIG. 10;
 FIG. 11D is a diagram illustrating Step 12 shown in FIG. 10; and
 FIG. 11E is a diagram illustrating Step 13 shown in FIG. 10.

[0014] Brief Description of Embodiments Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

[First Embodiment]

[Configuration]

[0015] The first embodiment is described with reference to FIG. 1, FIG. 2, FIG. 3, FIG. 4A, FIG. 4B, FIG. 4C, FIG. 5A, FIG. 5B, FIG. 6, FIG. 7A, FIG. 7B, FIG. 7C, FIG. 7D, FIG. 7E, FIG. 7F, FIG. 7G, FIG. 7H, FIG. 7I, FIG. 7J, FIG. 7K, FIG. 7L, and FIG. 7M. In some of the drawings, some components are not shown for clarity.

[Ultrasonic Treatment System (hereinafter, treatment system 10)]

[0016] As shown in FIG. 1, the treatment system 10 includes an ultrasonic treatment apparatus (hereinafter, treatment apparatus 20) which treats a treatment part such as a living tissue with ultrasonic vibration, and an electric source unit 90 which generates an electric current for the ultrasonic vibration of the treatment apparatus 20. The treatment system 10 further includes a cable 100 which supplies an electric current generated in the elec-

tric source unit 90 to the treatment apparatus 20 from the electric source unit 90 when one end of a cable 100a is connected to the treatment apparatus 20 and the other end portion of the cable 100a is connected to the electric source unit 90, and an input unit 110 such as a foot switch.

[Treatment Apparatus 20]

[0017] As shown in FIG. 1 and FIG. 2, the treatment apparatus 20 includes an ultrasonic vibrator unit (hereinafter, vibrator unit 40) which generates ultrasonic vibration by the electric current supplied from the electric source unit 90 via the cable 100, and an ultrasonic probe (hereinafter, probe 51) which is connected to the vibrator unit 40 and which is a transmission member to transmit the ultrasonic vibration generated in the vibrator unit 40. The treatment apparatus 20 further includes a sheath unit 60 into which the probe 51 is inserted, and a treatment portion 70 which treats the treatment part with the ultrasonic vibration transmitted by the probe 51.

[Vibrator Unit 40]

[0018] As shown in FIG. 1 and FIG. 2, the vibrator unit 40 includes an ultrasonic vibrator (hereinafter, vibrator 41) which generates ultrasonic vibration, and a case 49 which houses the vibrator 41.

[0019] As shown in FIG. 2, the vibrator 41 includes a piezoelectric element 43 which converts the electric current supplied from the electric source unit 90 to ultrasonic vibration, and a horn 45 which amplifies the amplitude of the ultrasonic vibration generated in the piezoelectric element 43.

[0020] As shown in FIG. 2, the piezoelectric element 43 has, for example, a ring-shape, and more than one piezoelectric element 43 is provided. The piezoelectric elements 43 are in close contact with one another along the longitudinal axis direction of the vibrator 41 (probe 51). The piezoelectric element 43 is connected to the cable 100.

[0021] As shown in FIG. 2, the horn 45 has, for example, a columnar shape, and is connected to the piezoelectric element 43. The horn 45 is attached to the case 49 so that the distal end portion of the horn 45 protrudes from the case 49. The horn 45 is an amplitude increasing portion which increases the amplitude of ultrasonic vibration.

[0022] This vibrator 41 is, for example, a bolt-clamped Langevin type transducer (BLT).

[Probe 51]

[0023] As shown in FIG. 2, the probe 51 is formed by an elongated member having a longitudinal axis. This probe 51 has the same thickness as, for example, that of the distal end portion of the horn 45. As shown in FIG. 2, the probe 51 includes one end portion 51a which is connected to one end portion 41a of the vibrator 41 rep-

representing the distal end portion of the horn 45, and the other end portion 51b which transmits ultrasonic vibration to the treatment part as shown in FIG. 1. The ultrasonic vibration is transmitted to the one end portion 51a from the vibrator 41. The ultrasonic vibration is then transmitted to the side of the other end portion 51b of the probe 51 from the one end portion 51a of the probe 51. The treatment portion 70 is formed in the other end portion 51b of the probe 51.

[Sheath Unit 60]

[0024] As shown in FIG. 1 and FIG. 2, the sheath unit 60 includes a sheath 61 through which the probe 51 is inserted, and a holding case 63 which is provided between the case 49 and the sheath 61 and which is coupled to the case 49 and which holds the case 49 and the sheath 61.

[0025] The sheath 61 has, for example, a cylindrical shape. The sheath 61 includes one end portion connected to the holding portion 63 as shown in FIG. 2, and the other end portion from which the other end portion 51b of the probe 51 protrudes as shown in FIG. 1.

[0026] The holding portion 63 has, for example, a cylindrical shape. The holding portion 63 includes a one end portion connected to the one end portion of the sheath 61, and the other end portion connected to the case 49. For example, inside the holding portion 63, the one end portion 51a of the probe 51 and the one end portion 41a of the vibrator 41 are connected to each other. In this case, the one end portion 51a of the probe 51 is inserted from the one end portion side of the holding portion 63, and the one end portion 41a of the vibrator 41 is inserted from the other end portion side of the holding portion 63.

[Treatment Portion 70]

[0027] As shown in FIG. 1, the treatment portion 70 includes the other end portion 51b of the probe 51 which ultrasonically vibrates.

[Electric Source Unit 90]

[0028] The electric source unit 90 includes an ultrasonic control portion 91a which is connected to the input unit 110 and which controls an electric current for ultrasonic vibration in accordance with an input amount of the input unit 110.

[Ultrasonic-vibration Generating/Transmitting Unit (hereinafter, Generating/Transmitting Unit 200) - Connection Mechanism 300]

[0029] As shown in FIG. 2 and FIG. 3, the treatment apparatus 20 further includes a generating/transmitting unit 200 which is constituted by parts connected to one another, generates ultrasonic vibration and transmits ul-

trasonic vibration to the treatment portion 70, and a connection mechanism 300 which is provided in each of parts constituting the generating/transmitting unit 200 and which connects the parts to one another to constitute the generating/transmitting unit 200.

[Generating/Transmitting Unit 200]

[0030] As shown in FIG. 2 and FIG. 3, the generating/transmitting unit 200 includes, for example, the vibrator 41 and the probe 51 that have been described above, according to the present embodiment. In this case, the vibrator 41 represents one of parts constituting the generating/transmitting unit 200, and the probe 51 represents the other part. In this way, the generating/transmitting unit 200 is constituted by more than one part.

[Connection Mechanism 300 provided in Vibrator 41]

[0031] As shown in FIG. 3, FIG. 4A, FIG. 4B, and FIG. 4C, the connection mechanism 300 includes the columnar one end portion 41a of the vibrator 41, and a held portion 41c which is provided on the outer circumferential surface of the one end portion 41a of the vibrator 41 and which is provided along the circumferential direction of the one end portion 41a. The connection mechanism 300 further includes an abutment portion 41e which is provided on the outer circumferential surface of the one end portion 41a of the vibrator 41 and which is provided along, for example, the axial direction of the one end portion 41a and which comes into abutment with a later-described cylinder-side protrusion portion 341c. The one end portion 41a of the vibrator 41 is one end portion representing one end portion of one of parts.

[0032] As shown in FIG. 3 and FIG. 4A, the held portion 41c and the abutment portion 41e are protrusion portions diametrically protruding from the outer circumferential surface of the one end portion 41a. The held portion 41c and the abutment portion 41e are, for example, columnar. The held portion 41c and the abutment portion 41e are, for example, integrated with the one end portion 41a. One end portion of the held portion 41c and one end portion of the abutment portion 41e are, for example, connected to each other, and the held portion 41c and the abutment portion 41e are integrated with each other. The held portion 41c and the abutment portion 41e function as a positioning portion 41g which positions the one end portion 41a relative to a later-described cylinder member 301.

[0033] As shown in FIG. 4B, the positioning portion 41g is substantially L-shaped. As shown in FIG. 4A and FIG. 4C, two positioning portions 41g, for example, are provided, and are provided 180 degrees apart from each other in the circumferential direction. For example, the positioning portions 41g are provided rotationally symmetrically with respect to the central axis of the one end portion 41a.

[0034] As shown in FIG. 4A, FIG. 4B, and FIG. 4C, the

one end portion 41a has an end face 411a provided at the extreme end in the axial direction of the vibrator 41. The held portion 41c has an end face 411c provided at the extreme end in the axial direction of the vibrator 41. The end face 411a and the end face 411c are formed in a plane that intersects at right angles with the axial direction of the one end portion 41a, and are flush. The end face 411a and the end face 411c are connected to each other, and are planes.

[0035] As shown in FIG. 7J and FIG. 7K, the held portion 41c is held between an end face 511a of the one end portion 51a of the probe 51 and the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301.

[0036] When the one end portion 41a of the vibrator 41 is inserted into the cylinder member 301 from a later-described cylinder-side one end portion 341a as shown in FIG. 7C, the abutment portion 41e is provided collinearly with the later-described cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301 as shown in FIG. 7D and FIG. 7E. When the held portion 41c is held between the end face 511a of the one end portion 51a of the probe 51 and the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301 as shown in FIG. 7J and FIG. 7K, the abutment portion 41e is in abutment with the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301.

[0037] As shown in FIG. 4A and FIG. 4C, the connection mechanism 300 includes a depression portion 41h which is depressed in the end face 411a and which is provided on the central axis of the vibrator 41. The depression portion 41h is, for example, columnar.

[0038] As shown in FIG. 4B and FIG. 4C, the length of the held portion 41c in the circumferential direction of the one end portion 41a is L1. As shown in FIG. 4C, the length from one held portion 41c to the other held portion 41c in the diametrical direction of the one end portion 41a is L2. As shown in FIG. 4B, the width of the held portion 41c is W1 in the axial direction of the one end portion 41a. As shown in FIG. 4B, the width of the abutment portion 41e is W2 in the axial direction of the one end portion 41a. As shown in FIG. 4B and FIG. 4C, the diameter of the end face 411a is D1.

[Connection Mechanism 300 provided in Probe 51]

[0039] As shown in FIG. 3, the connection mechanism 300 includes the columnar one end portion 51a of the probe 51 to be connected to the one end portion 41a of the vibrator 41, and a probe-side connection portion 51g which is provided on the outer circumferential surface of the one end portion 51a of the probe 51 and which is provided over, for example, the circumference of the one end portion 51a around the axis of the one end portion 51a. The one end portion 51a of the probe 51 is other end portion representing one end portion of the other part.

[0040] As shown in FIG. 2, the one end portion 51a

has substantially the same thickness as the one end portion 41a of the vibrator 41. As shown in FIG. 2, when the vibrator 41 and the probe 51 are connected to each other, the central axis of the probe 51 including the one end portion 51a is provided coaxially with the central axis of the vibrator 41 including the one end portion 41a.

[0041] As shown in FIG. 3, the one end portion 51a has the end face 511a provided at the extreme end in the axial direction of the probe 51. The end face 511a is a plane formed in a plane that intersects at right angles with the axial direction of the one end portion 51a. The end face 511a is substantially the same size as the end face 411a. A diameter D2 of the end face 511a is, for example, substantially the same as the length L2.

[0042] The probe-side connection portion 51g is, for example, a thread groove, and is the other connection portion.

[0043] As shown in FIG. 3, the connection mechanism 300 further includes a protrusion portion 51h which is provided to protrude from the end face 511a and which is provided on the central axis of the probe 51 and which is fitted into the depression portion 41h. The protrusion portion 51h is, for example, columnar.

[Components unique to Connection Mechanism 300]

[0044] As shown in FIG. 2 and FIG. 3, the connection mechanism 300 further includes the cylinder member 301.

[0045] As shown in FIG. 3, the cylinder member 301 has the cylinder-side one end portion 341a representing one end portion of the cylinder member 301 into which the one end portion 41a of the vibrator 41 is inserted, and a cylinder-side other end portion 351a representing the other end portion of the cylinder member 301 into which the one end portion 51a of the probe 51 is inserted.

[0046] As shown in FIG. 3, FIG. 5A, and FIG. 5B, the cylinder member 301 has the cylinder-side protrusion portion 341c which is provided on the inner circumferential surface of the cylinder-side one end portion 341a and which protrudes to inside of the cylinder member 301 from the inner circumferential surface and which is provided along the circumferential direction of the cylinder-side one end portion 341a. The cylinder member 301 further includes a cylinder-side connection portion 351g which is provided on the inner circumferential surface of the cylinder-side other end portion 351a and which is provided over the circumference of the cylinder-side other end portion 351a along the circumferential direction of the cylinder-side other end portion 351a and which is connected to the probe-side connection portion 51g when the one end portion 51a of the probe 51 is inserted into the cylinder-side other end portion 351a.

[0047] When the one end portion 51a of the probe 51 is inserted into the cylinder-side other end portion 351a as shown in FIG. 7A so that the cylinder-side connection portion 351g is connected to the probe-side connection portion 51g as shown in FIG. 7B, the cylinder-side pro-

trusion portion 341c protrudes from the inner circumferential surface collinearly with part of the end face 511a in the axial direction of the cylinder member 301 as shown in FIG. 7B. As shown in FIG. 5A and FIG. 5B, the cylinder-side protrusion portion 341c is integrated with the cylinder-side one end portion 341a.

[0048] The cylinder-side protrusion portion 341c has only to be provided in the same manner as the held portion 41c. Thus, as shown in FIG. 3 and FIG. 5A, two cylinder-side protrusion portions 341c, for example, are provided, and are provided 180 degrees apart from each other in the circumferential direction. As shown in FIG. 5A, the length of the cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301 is substantially the same as, for example, the length L1.

[0049] As shown in FIG. 3 and FIG. 5A, a space portion 303 is formed between one cylinder-side protrusion portion 341c and the other cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301. The space portion 303 has substantially the same shape as the held portion 41c. The space portion 303 is in communication with the inside of the cylinder member 301 in the axial direction of the cylinder member 301.

[0050] As shown in FIG. 5A, the length of the space portion 303 in the circumferential direction of the cylinder member 301 is W3. This length W3 represents the distance between one cylinder-side protrusion portion 341c and the other cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301. The length W3 is greater than the length L1, and the cylinder-side protrusion portions 341c are provided apart from each other in the circumferential direction of the cylinder member 301 so that the held portion 41c is inserted into the cylinder member 301 via the space portion 303 in the axial direction of the cylinder member 301.

[0051] That is, as shown in FIG. 5A, an inside diameter D2 of the one end portion 41a is substantially the same as the length L2 in the diametrical direction of the cylinder member 301. This inside diameter D2 represents the length from one space portion 303 to the other space portion 303.

[0052] As shown in FIG. 5A and FIG. 5B, a space portion 305 is formed between one cylinder-side protrusion portion 341c and the other cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301. The space portion 305 is in communication with the inside of the cylinder member 301 in the axial direction of the cylinder member 301. The space portion 305 is in communication with the space portion 303 in the diametrical direction of the cylinder member 301. The space portion 305 is held between the space portions 303.

[0053] The space portion 305 has substantially the same shape as the one end portion 41a of the vibrator 41. The length of the space portion 305 is D3 in the diametrical direction of the cylinder member 301. This length

D3 represents the distance between one cylinder-side protrusion portion 341c and the other cylinder-side protrusion portion 341c in the diametrical direction of the cylinder member 301. The cylinder-side protrusion portions 341c are provided apart from each other in the diametrical direction of the cylinder member 301 so that the length D3 is substantially the same as the diameter D1, the one end portion 41a of the vibrator 41 is inserted into the cylinder member 301 via the space portion 305 in the axial direction of the cylinder member 301.

[0054] As shown in FIG. 3, FIG. 5A, and FIG. 5B, the cylinder-side one end portion 341a has an end face 341b provided at the extreme end in the axial direction of the cylinder member 301. As shown in FIG. 3, FIG. 5A, and FIG. 5B, the cylinder-side protrusions 341c has an end face 341d provided at the extreme end in the axial direction of the cylinder member 301. As shown in FIG. 3, FIG. 5A, and FIG. 5B, the end face 341b and the end face 341d are formed in a plane that intersects at right angles with the axial direction of the cylinder member 301, and are flush. The end face 341b and the end face 341d are connected to each other, and are planes.

[0055] When the one end portion 51a of the probe 51 is inserted into the cylinder member 301 from the cylinder-side other end portion 351a as shown in FIG. 7A so that the probe-side connection portion 51g is connected to the cylinder-side connection portion 351g as shown in FIG. 7B, the cylinder-side protrusion portion 341c is provided at a distance equal to or more than the width W1 of the held portion 41c from the end face 511a in the axial direction of the cylinder member 301 as shown in FIG. 7B. At the same time, the cylinder-side protrusion portion 341c is provided relative to the end face 511a within the sum of the width W1 and the width W2 in the axial direction of the cylinder member 301. That is, as shown in FIG. 7B, $W1 < W4 < W1 + W2$, wherein W4 is the distance between the cylinder-side protrusion portion 341c and the end face 511a in the axial direction of the cylinder member 301.

[0056] The cylinder-side protrusion portion 341c is also provided so that the held portion 41c is provided between the end face 511a of the one end portion 51a and a plane where the cylinder-side protrusion portion 341c is provided as shown in FIG. 7E in the axial direction of the cylinder member 301 when the one end portion 41a of the vibrator 41 is inserted into the cylinder member 301 from the cylinder-side one end portion 341a as shown in FIG. 7C. The plane where the cylinder-side protrusion portion 341c is provided represents a plane in the diametrical direction of the cylinder member 301.

[0057] The cylinder-side protrusion portion 341c is also provided so that at least part of the abutment portion 41e is provided collinearly with the cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301 as shown in FIG. 7D and FIG. 7E when the one end portion 41a of the vibrator 41 is inserted into the cylinder member 301 from the cylinder-side one end portion 341a as shown in FIG. 7C.

[0058] The insertion of the one end portion 41a of the vibrator 41 into the cylinder member 301 from the cylinder-side one end portion 341a represents that the held portion 41c is inserted into the cylinder member 301 via the space portion 303 in the axial direction of the cylinder member 301, and at the same time, the one end portion 41a of the vibrator 41 is inserted into the cylinder member 301 via the space portion 305 in the axial direction of the cylinder member 301, as shown in FIG. 3.

[0059] The cylinder-side protrusion portion 341c is also provided so that the abutment portion 41e comes into abutment with the cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301 as shown in FIG. 7H and FIG. 7I when the one end portion 41a of the vibrator 41 is rotated relative to the cylinder member 301 around the axis of the cylinder member 301 as shown in FIG. 7F and FIG. 7G after the insertion of the one end portion 41a of the vibrator 41 into the cylinder member 301 from the cylinder-side one end portion 341a as shown in FIG. 7C. The cylinder-side protrusion portion 341c regulates the rotation of the one end portion 41a of the vibrator 41 relative to the cylinder member 301 when the abutment portion 41e comes into abutment with the cylinder-side protrusion portion 341c.

[0060] The cylinder-side protrusion portion 341c is also provided so that the held portion 41c is provided between the end face 511a and the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301 while the abutment portion 41e is in abutment with the cylinder-side protrusion portion 341c as shown in FIG. 7I.

[0061] The cylinder-side protrusion portion 341c is also provided so that the held portion 41c is held between the end face 511a and the cylinder-side protrusion portion 341c as shown in FIG. 7J and FIG. 7K when at least one of the one end portion 41a of the vibrator 41 and the one end portion 51a of the probe 51 is rotated relative to the cylinder member 301 around the axis of the cylinder member 301 and then further inserted into the cylinder member 301 so that the width W4 which is the distance between the end face 511a and the cylinder-side protrusion portion 341c is reduced to the width W1 as shown in FIG. 7J and FIG. 7K. Here, the held portion 41c is provided between the end face 511a and the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301 while the abutment portion 41e is in abutment with the cylinder-side protrusion portion 341c. As shown in FIG. 7J and FIG. 7K, the cylinder-side protrusion portion 341c is then provided so that the held portion 41c is in close contact with the end face 511a without any space therebetween and so that the held portion 41c is in close contact with the cylinder-side protrusion portion 341c without any space therebetween.

[0062] The cylinder-side connection portion 351g is, for example, a thread groove which engages with the probe-side connection portion 51g.

[Production Method for Generating/Transmitting Unit 200 - FIG. 6]

[Step 1 - Process of Temporarily Connecting Cylinder Member 301 and Probe 51 - FIG. 6, FIG. 7A, and FIG. 7B]

[0063] The probe-side connection portion 51g and the cylinder-side connection portion 351g are connected to each other in the axial direction of the cylinder member 301, and the one end portion 51a of the probe 51 is inserted into the cylinder member 301 from the cylinder-side other end portion 351a as shown in FIG. 7A so that the end face 511a is provided at a distance equal to or more than the width W1 from the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301 as shown in FIG. 7B. At the same time, the one end portion 51a is inserted into the cylinder member 301 if one of the one end portion 51a and the cylinder-side other end portion 351a is rotated halfway relative to the other.

[0064] The one end portion 51a is inserted into the cylinder-side other end portion 351a so that the abutment portion 41e will come into abutment with the cylinder-side protrusion portion 341c when at least part of the abutment portion 41e is provided collinearly with the cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301 in later-described Step 2 (see FIG. 7E) and when the one end portion 41a of the vibrator 41 is rotated relative to the cylinder member 301 in Step 3 (see FIG. 7G and FIG. 7I).

[Step 2 - Process of Inserting Vibrator 41 into Cylinder Member 301 - FIG. 6, FIG. 7C, FIG. 7D, and FIG. 7E]

[0065] The held portion 41c is inserted into the cylinder member 301 via the space portion 303 in the axial direction of the cylinder member 301 as shown in FIG. 7C and FIG. 7D so that the protrusion portion 51h is fitted into the depression portion 41h as shown in FIG. 7E. At the same time, the one end portion 41a of the vibrator 41 is inserted into the cylinder member 301 via the space portion 305 in the axial direction of the cylinder member 301 as shown in FIG. 7C and FIG. 7D.

[0066] Here, the one end portion 41a of the vibrator 41 is inserted into the cylinder member 301 from the cylinder-side one end portion 341a in the axial direction of the cylinder member 301 so that the held portion 41c is provided between the end face 511a and the plane where the cylinder-side protrusion portion 341c is provided in the axial direction of the cylinder member 301 as shown in FIG. 7E. At the same time, the one end portion 41a of the vibrator 41 is inserted into the cylinder member 301 from the cylinder-side one end portion 341a in the axial direction of the cylinder member 301 so that the at least part of the abutment portion 41e is provided collinearly with the cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301 as shown in FIG. 7D and FIG. 7E.

[0067] Here, the one end portion 41a is also inserted

into the cylinder member 301 from the cylinder-side one end portion 341a so that the end face 411a and the end face 411c will come into abutment with the end face 511a as shown in FIG. 7E.

[Step 3 - Process of Temporarily Connecting Cylinder Member 301 and Vibrator 41 - FIG. 6, FIG. 7F, FIG. 7G, FIG. 7H, and FIG. 7I]

[0068] The one end portion 41a of the vibrator 41 is rotated halfway relative to the cylinder member 301 around the axis of the cylinder member 301 as shown in FIG. 7F and FIG. 7G so that the abutment portion 41e will come into abutment with the cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301 as shown in FIG. 7H and FIG. 7I and in this abutment condition, the held portion 41c is provided between the end face 511a and the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301 as shown in FIG. 7H and FIG. 7I.

[Step 4 - Process of Connecting Vibrator 41 and Probe 51 - FIG. 6, FIG. 7J, and FIG. 7K]

[0069] At least one of the one end portion 41a of the vibrator 41 and the one end portion 51a of the probe 51 is rotated around the axis of the cylinder member 301 and further inserted into the cylinder member 301 so that the width W4 shown in FIG. 7B which is the distance between the end face 511a and the cylinder-side protrusion portion 341c is reduced to the width W1 shown in FIG. 7J and so that the held portion 41c is held between the end face 511a and the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301 as shown in FIG. 7J and FIG. 7K. FIG. 7K is a diagram showing the condition in FIG. 7J seen from another position.

[0070] Here, for example, the one end portion 41a is rotated halfway clockwise relative to the cylinder member 301, and the one end portion 51a is rotated halfway counterclockwise relative to the cylinder member 301.

[0071] As a result, from the condition in Step 1, the probe-side connection portion 51g and the cylinder-side connection portion 351g further engage with each other, and the one end portion 51a is further inserted into the cylinder member 301 from the cylinder-side other end portion 351a as shown in FIG. 7J and FIG. 7K.

[0072] When the held portion 41c is held between the end face 511a and the cylinder-side protrusion portion 341c as shown in FIG. 7K and FIG. 7J, the held portion 41c is in close contact with the end face 511a without any space therebetween, and in close contact with the cylinder-side protrusion portion 341c without any space therebetween. Thus, the vibrator 41 and the probe 51 are firmly connected to each other without being out of alignment in the axial direction and the circumferential direction.

[0073] As shown in FIG. 7K and FIG. 7J, since the abut-

ment portion 41e comes into abutment with the cylinder-side protrusion portion 341c, the vibrator 41 and the probe 51 are more firmly connected to each other without being out of alignment in the circumferential direction.

[Step 5 - Process of Disconnecting Vibrator 41 and Probe 51 - FIG. 6, FIG. 7L, and FIG. 7M]

[0074] From the condition in Step 4, for example, the one end portion 51a is rotated halfway clockwise relative to the cylinder member 301 so that the held portion 41c will be separated from the cylinder-side protrusion portion 341c and the held portion 41c will be released from the condition in which the held portion 41c is held between the end face 511a and the cylinder-side protrusion portion 341c as shown in FIG. 7L.

[0075] The one end portion 41a of the vibrator 41 is then rotated, for example, halfway counterclockwise relative to the cylinder member 301 so that the abutment portion 41e will be separated from the cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301 and so that the held portion 41c will be provided in the space portion 303 in the axial direction of the cylinder member 301 as shown in FIG. 7L.

[0076] As shown in FIG. 7M, the one end portion 41a of the vibrator 41 is then removed from the cylinder member 301 in the axial direction of the cylinder member 301.

[Advantageous Effects in Connection Processes (Steps 1, 2, 3, and 4)]

[0077] According to the present embodiment, the vibrator 41 and the probe 51 are connected to each other by the cylinder member 301 as described above.

[0078] However, according to the present embodiment, in the production method for the generating/transmitting unit 200, after the vibrator 41 and the probe 51 are connected to each other, it is not necessary that the probe 51 be inserted into the cylinder member 301 from the other end portion 51b of the probe 51, that the cylinder member 301 slide on the probe 51 toward the one end portion 51a from the other end portion 51b of the probe 51, that the cylinder member 301 be rotated more than once, and that the cylinder member 301 fasten the connection part between the vibrator 41 and the probe 51 by rotation.

[0079] According to the present embodiment, the vibrator 41 is temporarily connected to the cylinder member 301 as shown in Steps 2 and 3 while the cylinder member 301 is temporarily connected to the one end portion 51a of the probe 51 as shown in Step 1. Finally, as shown in Step 4, the vibrator 41 and the probe 51 then rotate halfway relative to each other, and the held portion 41c is held by the end face 511a and the cylinder-side protrusion portion 341c, so that the vibrator 41 and the probe 51 are connected to each other.

[0080] Thus, according to the present embodiment, the number of rotations of the cylinder member 301 can be

reduced, and the connecting operation can be performed without any trouble.

[0081] According to the present embodiment, since the end face 511a and the cylinder-side protrusion portion 341c hold the held portion 41c in between, the vibrator 41 and the probe 51 can be firmly connected to each other without being out of alignment in the axial direction and the circumferential direction.

[0082] According to the present embodiment, since the abutment portion 41e comes into abutment with the cylinder-side protrusion portion 341c, the vibrator 41 and the probe 51 can be more firmly connected to each other without being out of alignment in the circumferential direction, and the rotation of the vibrator 41 can be regulated.

[0083] According to the present embodiment, since the vibrator 41 and the probe 51 can be firmly connected to each other, ultrasonic vibration can be fully transmitted to the probe 51 from the vibrator 41.

[0084] According to the present embodiment, in Step 2, since the protrusion portion 51h is fitted into the depression portion 41h, the vibrator 41 can be easily positioned relative to the probe 51. Moreover, according to the present embodiment, since the space portion 303 has substantially the same shape as the held portion 41c, and the space portion 305 has substantially the same shape as the one end portion 41a, vibrator 41 can be easily positioned relative to the probe 51.

[0085] According to the present embodiment, a manufacturer can perform the process in Step 1, for example, at a manufacturing factory, and the user who uses the treatment apparatus 20 can perform the processes in Steps 2, 3, and 4. Therefore, according to the present embodiment, it is possible to save the user the trouble and improve usability.

[0086] According to the present embodiment, since, for example, the cylinder member 301 does not need to slide on the probe 51 during the connecting operation, it is possible to prevent the cylinder member 301 from being worn by sliding.

[0087] According to the present embodiment, the held portion 41c and the abutment portion 41e are provided in the one end portion 41a of the vibrator 41, and the end face 411a and the end face 411c are flush, so that the cylinder member 301 can be reduced in length.

[0088] According to the present embodiment, since the end face 511a is substantially the same size as the end face 411a, ultrasonic vibration can be fully transmitted to the probe 51 from the vibrator 41.

[Advantageous Effects in Disconnection Process (Step 5)]

[0089] According to the present embodiment, the cylinder member 301 does not need to be separated from the vibrator 41 and the probe 51 as shown in Step 5. Thus, according to the present embodiment, in the disconnecting operation, the number of rotations of the cyl-

inder member 301 can be reduced, and the disconnecting operation can be performed without any trouble.

[0090] According to the present embodiment, in the disconnecting operation, for example, the cylinder member 301 does not need to slide on the probe 51 toward the other end portion 51b from the one end portion 51a of the probe 51. Therefore, according to the present embodiment, it is possible to prevent the cylinder member 301 from being worn by sliding.

[0091] According to the present embodiment, the flow returns to Step 2 after Step 5, so that the probe 51 can be quickly replaced.

[0092] According to the present embodiment, the vibrator 41 has the held portion 41c and the abutment portion 41e, and the probe 51 has the probe-side connection portion 51g. However, the present invention does not need to be limited to this. It is only necessary that one of the vibrator 41 and the probe 51 have either the held portion 41c and the abutment portion 41e or the probe-side connection portion 51g, and that the other of the vibrator 41 and the probe 51 have either the held portion 41c and the abutment portion 41e or the probe-side connection portion 51g. Accordingly, the cylinder member 301 has only to have the cylinder-side protrusion portion 341c on the side of the held portion 41c and the abutment portion 41e, and have the cylinder-side connection portion 351g on the side of the probe-side connection portion 51g.

[0093] According to the present embodiment, the abutment portion 41e is provided along the axial direction of the one end portion 41a, and connected to the held portion 41c. However, it is only necessary that the abutment portion 41e can come into abutment with the cylinder-side protrusion portion 341c in Step 3. Thus, the abutment portion 41e has only to be provided to come into abutment with the cylinder-side protrusion portion 341c in the circumferential direction of the cylinder member 301 when the held portion 41c is held by the end face 511a and the cylinder-side protrusion portion 341c. Therefore, the abutment portion 41e is not particularly limited in its location, shape, and size.

[Modifications]

[0094] According to the present embodiment, since the held portion 41c is held by the end face 511a and the cylinder-side protrusion portion 341c, the vibrator 41 and the probe 51 are firmly connected to each other without being out of alignment in the axial direction and the circumferential direction. Therefore, as shown in FIG. 8, the held portion 41c alone has only to be provided, and the abutment portion 41e does not always need to be provided. In this case, for example, in Step 4, since the cylinder member 301 or the probe 51, for example, is rotated, the held portion 41c is held by the end face 511a and the cylinder-side protrusion portion 341c.

[0095] When, for example, the held portion 41c alone is provided, the protrusion portion 51h and the depres-

sion portion 41h do not need to be columnar. In this case, the protrusion portion 51h and the depression portion 41h may have a shape such as a rectangular shape that prevents the vibrator 41 from being rotated relative to the probe 51. In this case, for example, in Step 4, the cylinder member 301, for example, is rotated, so that the held portion 41c is held by the end face 511a and the cylinder-side protrusion portion 341c. In this case, according to the present embodiment, the vibrator 41 and the probe 51 can be positioned in the circumferential direction, and can be firmly connected to each other without being out of alignment in the circumferential direction.

[Second Embodiment]

[Differences between Second Embodiment and First Embodiment]

[0096] According to the first embodiment, the one end portion 41a of the vibrator 41 is inserted into the cylinder member 301 in the axial direction of the cylinder member 301, as shown in FIG. 3. However, the one end portion 41a of the vibrator 41 according to the present embodiment slides on to the cylinder member 301 in the diametrical direction of the cylinder member 301 and is thereby inserted into the cylinder member 301, as shown in FIG. 9.

[Configuration]

[Vibrator 41]

[0097] As shown in FIG. 9, the vibrator 41 includes the columnar one end portion 41a, and the columnar other end portion 41b which is provided coaxially with the one end portion 41a and which is thicker than the one end portion 41a.

[0098] The one end portion 41a is formed by a cutout end portion 41m connected to the other end portion 41b, and a columnar edge end portion 41n which is provided coaxially with the cutout end portion 41m and which is connected to the cutout end portion 41m.

[0099] The cutout end portion 41m has the shape of a column that is partly cut out. The cutout end portion 41m has, for example, a rectangular planar portion 411m formed by being cut out. The planar portion 411m is depressed from the outer circumferential surface of the cutout end portion 41m toward the central axis of the one end portion 41a. The planar portion 411m has a length L3 in the diametrical direction of the one end portion 41a which intersects at right angles with the depression direction, and has a width L4 in the axial direction of the one end portion 41a. The planar portion 411m is connected to the circumferential surface of the cutout end portion 41m. Two planar portions 411m, for example, are provided, and are provided 180 degrees apart from each other in the circumferential direction.

[0100] The cutout end portion 41m has a section

formed along a sliding direction that intersects at right angles with the plane direction of the planar portion 411m. This section is formed by the planar portions 411m as an elliptic shape having two straight lines provided parallel to each other. More specifically, the section is formed by two straight lines parallel to each other, and two arcs which form part of a circle and which are connected to the ends of the straight lines.

[0101] The planar portion 411m functions as a prevention mechanism 600 which is provided on the outer circumferential surface of the one end portion 41a of the vibrator 41 and which prevents the one end portion 41a of the vibrator 41 inserted in the cylinder-side one end portion 341a from being rotated relative to the cylinder member 301 around the axis of the cylinder member 301.

[0102] The edge end portion 41n has a columnar shape. The edge end portion 41n has the held portion 41c. This held portion 41c is a protrusion portion formed by part of the edge end portion 41n diametrically protruding relative to the planar portion 411m. The length of the edge end portion 41n including the held portion 41c is W1.

[Connection Mechanism 300 provided in Vibrator 41]

[0103] As shown in FIG. 9, the connection mechanism 300 includes the cutout end portion 41m and the edge end portion 41n that constitute the one end portion 41a of the vibrator 41, and the held portion 41c formed in the edge end portion 41n.

[Connection Mechanism 300 provided in Probe 51]

[0104] As shown in FIG. 9, the protrusion portion 51h is omitted. In other respects, the connection mechanism 300 provided in the probe 51 is similar in configuration to that according to the first embodiment.

[Cylinder Member 301]

[0105] As shown in FIG. 9, the cylinder member 301 has an opening portion 307 which is provided in the circumferential surface of the cylinder-side one end portion 341a of the cylinder member 301 and which is in communication with the inside the cylinder member 301 and the prevention mechanism 600 provided on the inner circumferential surface of the cylinder-side one end portion 341a. The opening portion 307 is provided so that the one end portion 41a of the vibrator 41 slides on the cylinder member 301 in the diametrical direction of the cylinder member 301 and is thereby inserted into the cylinder member 301 and provided in the cylinder member 301.

[0106] As shown in FIG. 9, the opening portion 307 is formed by a cutout opening portion 309 in which the cutout end portion 41m is inserted and provided in the cylinder member 301 in the diametrical direction of the cylinder member 301, and an edge end opening portion 311 in which the edge end portion 41n is inserted and pro-

vided in the cylinder member 301 in the diametrical direction of the cylinder member 301.

[0107] As shown in FIG. 9, the cutout opening portion 309 is regulated by protruding toward the central axis of the cylinder member 301 so that an edge portion 341f of the cylinder-side one end portion 341a is substantially U-shaped and so that the inner circumferential surface of the edge portion 341f will come into abutment with the held portion 41c formed in the planar portion 411m and the cutout end portion 41m. In other words, the inner circumferential surface of the edge portion 341f has two planar portions 341g which are substantially the same size as the planar portion 411m, and a circumferential surface 341h which is substantially the same size as part of the circumferential surface of the cutout end portion 41m. The cutout opening portion 309 is then regulated by the planar portions 341g and the circumferential surface 341h.

[0108] The cutout opening portion 309 is substantially the same size as the cutout end portion 41m, and positions the cutout end portion 41m.

[0109] The protruding amount of the edge portion 341f is substantially the same as the depressing amount of the planar portion 411m and the protruding amount of the held portion 41c.

[0110] In the axial direction of the cylinder member 301, the length of the edge portion 341f is substantially the same as the length L4 of the planar portion 411m.

[0111] In the diametrical direction of the cylinder member 301, the length of the planar portion 341g is substantially the same as the length L3 of the planar portion 411m.

[0112] As shown in FIG. 11C and FIG. 11D, when the cutout end portion 41m is inserted into the cutout opening portion 309 in the diametrical direction of the cylinder member 301, the planar portion 411m slides on the planar portion 341g, and the circumferential surface of the cutout end portion 41m comes into abutment with the circumferential surface 341h.

[0113] As shown in FIG. 11C and FIG. 11D, the planar portion 341g comes into abutment with the planar portion 411m, and thereby prevents the one end portion 41a from being rotated relative to the cylinder member 301. Thus, the planar portion 341g, the circumferential surface 341h, and the cutout opening portion 309 function as the prevention mechanism 600 which is provided on the inner circumferential surface of the cylinder-side one end portion 341a and which prevents the one end portion 41a of the vibrator 41 inserted in the cylinder-side one end portion 341a from being rotated relative to the cylinder member 301 around the axis of the cylinder member 301.

[0114] As shown in FIG. 9 and FIG. 11D, the protruding edge portion 341f functions as the cylinder-side protrusion portion 341c which comes into abutment with the held portion 41c when the edge end portion 41n is inserted and provided in the cylinder member 301 via the edge end opening portion 311 in the diametrical direction of the cylinder member 301. The cylinder-side protrusion

portion 341c comes into abutment with the held portion 41c, and thereby prevents the one end portion 41a from being removed from the cylinder-side one end portion 341a of the cylinder member 301.

[0115] The edge end opening portion 311 is substantially the same size as the edge end portion 41n, and positions the edge end portion 41n.

[0116] Thus, the opening portion 307 is provided so that the one end portion 41a of the vibrator 41 slides on the cylinder member 301 via the opening portion 307 in the diametrical direction of the cylinder member 301 and is thereby inserted into the cylinder member 301, so that the inserted held portion 41c is provided between the end face 511a and the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301, and so that the rotation of the inserted one end portion 41a of the vibrator 41 relative to the cylinder member 301 around the axis of the cylinder member 301 is prevented by the prevention mechanism 600.

[0117] Thus, since the rotation of the one end portion 41a of the vibrator 41 is prevented, the cylinder-side protrusion portion 341c is provided so that the held portion 41c is held by the end face 511a and the cylinder-side protrusion portion 341c when the one end portion 51a of the probe 51 is rotated relative to the cylinder member 301 around the axis of the cylinder member 301 and then further inserted into the cylinder member 301 so that the width W1 which is the distance between the end face 511a and the cylinder-side protrusion portion 341c is reduced.

[Production Method for Generating/Transmitting Unit 200]

[Step 11 - Process of Temporarily Connecting Cylinder Member 301 and Probe 51 - FIG. 10, FIG. 11A, and FIG. 11B]

[0118] Step 11 is substantially similar to Step 1.

[0119] The one end portion 51a of the probe 51 is inserted into the cylinder member 301 from the cylinder-side other end portion 351a as shown in FIG. 11A while the probe-side connection portion 51g and the cylinder-side connection portion 351g are connected to each other in the axial direction of the cylinder member 301 so that the end face 511a is provided at a distance equal to or more than the width W1 from the cylinder-side protrusion portion 341c functioning as the edge portion 341f in the axial direction of the cylinder member 301 as shown in FIG. 11B. Here, the one end portion 51a is inserted into the cylinder member 301 if one of the one end portion 51a and the cylinder-side other end portion 351a is, for example, rotated halfway relative to the other.

[Step 12 - Process of Inserting and Temporarily Connecting Vibrator 41 into Cylinder Member 301 - FIG. 11C and FIG. 11D]

[0120] The one end portion 41a slides on the cylinder member 301 via the opening portion 307 in the diametrical direction of the cylinder member 301 and is thereby inserted into the cylinder member 301 as shown in FIG. 11C and FIG. 11D so that the inserted held portion 41c is provided between the end face 511a and the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301 and so that the rotation of the inserted one end portion 41a of the vibrator 41 relative to the cylinder member 301 around the axis of the cylinder member 301 is prevented by the prevention mechanism 600.

[0121] More specifically, the cutout end portion 41m is inserted from the cutout opening portion 309 and then provided in the cutout opening portion 309 as shown in FIG. 11C and FIG. 11D, and at the same time, the edge end portion 41n is inserted into the edge end opening portion 311 and provided in the edge end opening portion 311.

[0122] Here, as shown in FIG. 11D, the planar portion 411m of the cutout end portion 41m slides on the planar portion 341g, and the circumferential surface 341h comes into abutment with the circumferential surface of the cutout end portion 41m. As a result, the rotation of the one end portion 41a relative to the cylinder member 301 is prevented.

[0123] At the same time, the held portion 41c slides on the cylinder-side protrusion portion 341c functioning as the edge portion 341f. The removal of the one end portion 41a from the one end portion of the cylinder member 301 is prevented.

[Step 13 - Process of Connecting Vibrator 41 and Probe 51 - FIG. 11E]

[0124] The one end portion 51a of the probe 51 is rotated around the axis of the cylinder member 301 and further inserted into the cylinder member 301 so that the width W4 which is the distance between the end face 511a and the cylinder-side protrusion portion 341c is reduced to the width W1 and so that the held portion 41c is held between the end face 511a and the cylinder-side protrusion portion 341c in the axial direction of the cylinder member 301, as shown in FIG. 11E. For example, the one end portion 51a of the probe 51 is rotated halfway counterclockwise relative to the cylinder member 301.

[0125] Here, from the condition in Step 11, the one end portion 51a of the probe 51 is further inserted into the cylinder-side other end portion 351a.

[0126] When the held portion 41c is held by the end face 511a and the cylinder-side protrusion portion 341c functioning as the edge portion 341f, the held portion 41c is in close contact with the end face 511a without any space therebetween, and in close contact with the cylin-

der-side protrusion portion 341c functioning as the edge portion 341f without any space therebetween. Thus, the vibrator 41 and the probe 51 are firmly connected to each other without being out of alignment in the axial direction and the circumferential direction.

[0127] Since the planar portion 341g comes into abutment with the planar portion 411m, the vibrator 41 and the probe 51 are more firmly connected to each other without being out of alignment in the circumferential direction.

[Step 14 - Process of Disconnecting Vibrator 41 and Probe 51]

[0128] From the condition in Step 13 shown in FIG. 11E, the one end portion 51a of the probe 51 is rotated, for example, halfway clockwise relative to the cylinder member 301 so that the end face 511a will be separated from the held portion 41c and the held portion 41c will be released from the condition in which the held portion 41c is held between the end face 511a and the cylinder-side protrusion portion 341c functioning as the edge portion 341f.

[0129] The one end portion 41a of the vibrator 41 then slides on the cylinder member 301 via the opening portion 307 in the diametrical direction of the cylinder member 301 and is thereby removed from the cylinder member 301 as shown in FIG. 11C and FIG. 11D.

[Advantageous Effects]

[0130] Thus, according to the present embodiment, the one end portion 41a of the vibrator 41 slides on the cylinder member 301 via the opening portion 307 in the diametrical direction of the cylinder member 301, so that advantageous effects similar to those according to the first embodiment can be obtained even if the one end portion 41a of the vibrator 41 is inserted into or removed from the cylinder member 301.

[0131] According to the first and second embodiments, the vibrator 41 which is one part constituting the generating/transmitting unit 200 and the probe 51 which is the other part constituting the generating/transmitting unit 200 have been described by way of example in the operation of connecting and disconnecting the parts constituting the generating/transmitting unit 200. However, the present invention does not need to be limited to this. For example, when the probe 51 is formed by more than one component, the first and second embodiments are applicable to both the connection and disconnection of one component and the other component.

[0132] Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the ap-

pendent claims and their equivalents.

Claims

1. A connection mechanism for an ultrasonic-vibration generating/transmitting unit, the connection mechanism being provided in each of parts constituting the ultrasonic-vibration generating/transmitting unit which generates and transmits ultrasonic vibration, the connection mechanism connecting the parts to each other to form the ultrasonic-vibration generating/transmitting unit, the connection mechanism comprising:

one end portion representing one end portion of one of the parts;

a held portion which is provided on the outer circumferential surface of the one end portion and which is provided along the circumferential direction of the one end portion;

other end portion representing one end portion of the other part which is connected to the one end portion;

other connection portion which is provided on the outer circumferential surface of the other end portion and which is provided over the circumference of the other end portion along the circumferential direction of the other end portion; and

a cylinder member, the cylinder member comprising a cylinder-side one end portion into which the one end portion is inserted, a cylinder-side other end portion into which the other end portion is inserted, a cylinder-side protrusion portion which is provided on the inner circumferential surface of the cylinder-side one end portion and which protrudes inward from the inner circumferential surface and which is provided along the circumferential direction of the cylinder-side one end portion, and a cylinder-side connection portion which is provided on the inner circumferential surface of the cylinder-side other end portion and which is provided over the circumference of the cylinder-side other end portion along the circumferential direction of the cylinder-side other end portion,

wherein when the one end portion is inserted into the cylinder member from the cylinder-side one end portion and when the other end portion is inserted into the cylinder member from the cylinder-side other end portion so that the other connection portion is connected to the cylinder-side connection portion, the held portion is held by the end face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member, whereby the one end portion and the other end portion are con-

nected to each other.

2. The connection mechanism for the ultrasonic-vibration generating/transmitting unit according to claim 1, wherein when the other end portion is inserted into the cylinder member from the cylinder-side other end portion so that the other end portion is connected to the cylinder-side connection portion, the cylinder-side protrusion portion is provided at a distance greater than a width W1 of the held portion from the end face of the other end portion in the axial direction of the cylinder member.
3. The connection mechanism for the ultrasonic-vibration generating/transmitting unit according to claim 2, further comprising an abutment portion which is provided on the outer circumferential surface of the one end portion and which comes into abutment with the cylinder-side protrusion portion in the circumferential direction of the cylinder member when the held portion is held by the end face of the other end portion and the cylinder-side protrusion portion, wherein when the one end portion is inserted into the cylinder member from the cylinder-side one end portion along the axial direction of the cylinder member, the held portion is provided between the end face of the other end portion and a plane where the cylinder-side protrusion portion is provided in the axial direction of the cylinder member, and the abutment portion is provided collinearly with the cylinder-side protrusion portion in the circumferential direction of the cylinder member.
4. The connection mechanism for the ultrasonic-vibration generating/transmitting unit according to claim 3, wherein when the one end portion is rotated relative to the cylinder member around the axis of the cylinder member after the insertion of the one end portion into the cylinder member from the cylinder-side one end portion, in the circumferential direction of the cylinder member, the abutment portion comes into abutment with the cylinder-side protrusion portion, and in this abutment condition, the held portion is provided between the end face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member.
5. The connection mechanism for the ultrasonic-vibration generating/transmitting unit according to claim 4, wherein when at least one of the one end portion and the other end portion is rotated relative to the cylinder member around the axis of the cylinder member and then further inserted into the cylinder member so that a distance W4 between the end face of the other end portion and the cylinder-side protrusion portion is reduced, the held portion is held be-

tween the end face of the other end portion and the cylinder-side protrusion portion.

6. The connection mechanism for the ultrasonic-vibration generating/transmitting unit according to claim 5, further comprising:

a depression portion provided in one of the end face of the one end portion and the end face of the other end portion; and
a protrusion portion which is provided in the other of the end face of the one end portion and the end face of the other end portion and which is fitted into the depression portion when the one end portion and the other end portion are inserted into the cylinder member.

7. The connection mechanism for the ultrasonic-vibration generating/transmitting unit according to claim 2, further comprising a prevention mechanism which is provided on the inner circumferential surface of the cylinder-side one end portion and the outer circumferential surface of the one end portion and which prevents the one end portion inserted in the cylinder-side one end portion from being rotated relative to the cylinder member around the axis of the cylinder member,
wherein the cylinder member further comprises an opening portion which is provided in the circumferential surface of the cylinder-side one end portion and which is in communication with the inside of the cylinder member and the prevention mechanism provided on the inner circumferential surface of the cylinder-side one end portion, and
the opening portion is provided so that the one end portion slides on the cylinder member via the opening portion in the diametrical direction of the cylinder member and is thereby inserted into the cylinder member, so that the inserted held portion is provided between the end face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member, and so that the rotation of the inserted one end portion relative to the cylinder member around the axis of the cylinder member is prevented by the prevention mechanism.

8. The connection mechanism for the ultrasonic-vibration generating/transmitting unit according to claim 7, wherein when the other end portion is further inserted into the cylinder member from the cylinder-side other end portion so that a width W4 which is the distance between the end face of the other end portion and the cylinder-side protrusion portion is reduced, the held portion is held between the end face of the other end portion and the cylinder-side protrusion portion.

9. A production method for an ultrasonic-vibration gen-

erating/transmitting unit to connect parts constituting the ultrasonic-vibration generating/transmitting unit which generates and transmits ultrasonic vibration to form the ultrasonic-vibration generating/transmitting unit,
wherein there are provided:

one end portion representing one end portion of one of the parts;
a held portion which is provided on the outer circumferential surface of the one end portion and which is provided along the circumferential direction of the one end portion;
other end portion representing one end portion of the other part which is connected to the one end portion;
other connection portion which is provided on the outer circumferential surface of the other end portion and which is provided over the circumference of the other end portion along the circumferential direction of the other end portion; and
a cylinder member, the cylinder member comprising a cylinder-side one end portion into which the one end portion is inserted, a cylinder-side other end portion into which the other end portion is inserted, a cylinder-side protrusion portion which is provided on the inner circumferential surface of the cylinder-side one end portion and which protrudes inward from the inner circumferential surface and which is provided along the circumferential direction of the cylinder-side one end portion, and a cylinder-side connection portion which is provided on the inner circumferential surface of the cylinder-side other end portion and which is provided over the circumference of the cylinder-side other end portion along the circumferential direction of the cylinder-side other end portion,
the production method comprising a process of connecting one of the part and the other part, the connection process comprising inserting one end portion into the cylinder member from the cylinder-side one end portion so that the held portion is held by the end face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member, inserting the other end portion into the cylinder member from the cylinder-side other end portion so that the other connection portion is connected to the cylinder-side connection portion, and thereby connecting the one end portion and the other end portion to each other.

10. The production method for the transmitting unit according to claim 9, further comprising a process of temporarily connecting the cylinder member and the other part wherein the other end portion is inserted

into the cylinder member from the cylinder-side other end portion while the other end portion is connected to the cylinder-side connection portion so that the end face of the other end portion is provided at a distance greater than a width W1 of the held portion from the cylinder-side protrusion portion in the axial direction of the cylinder member.

11. The production method for the transmitting unit according to claim 10, wherein there are further provided an abutment portion which is provided on the outer circumferential surface of the one end portion and which comes into abutment with the cylinder-side protrusion portion in the circumferential direction of the cylinder member when the held portion is held by the end face of the other end portion and the cylinder-side protrusion portion, the production method further comprising a process of inserting one of the parts into the cylinder member wherein the one end portion is inserted into the cylinder member from the cylinder-side one end portion so that the held portion is provided between the end face of the other end portion and a plane where the cylinder-side protrusion portion is provided in the axial direction of the cylinder member and so that the abutment portion is provided collinearly with the cylinder-side protrusion portion in the circumferential direction of the cylinder member.

12. The production method for the transmitting unit according to claim 11, further comprising a process of temporarily connecting the cylinder member and one of the parts wherein the one end portion is rotated relative to the cylinder member around the axis of the cylinder member after the insertion of the one end portion into the cylinder member from the cylinder-side one end portion so that the abutment portion comes into abutment with the cylinder-side protrusion portion in the circumferential direction of the cylinder member, and in this abutment condition, the held portion is provided between the end face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member.

13. The production method for the transmitting unit according to claim 12, further comprising a connection process wherein at least one of the one end portion and the other end portion is rotated around the axis of the cylinder member and then further inserted into the cylinder member so that a width W4 which is the distance between the end face of the other end portion and the cylinder-side protrusion portion is reduced and so that the held portion is held between the end face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member.

14. The production method for the transmitting unit ac-

cording to claim 10, wherein there are further provided a prevention mechanism which is provided on the inner circumferential surface of the cylinder-side one end portion and the outer circumferential surface of the one end portion and which prevents the one end portion inserted in the cylinder-side one end portion from being rotated relative to the cylinder member around the axis of the cylinder member, and the cylinder member further comprises an opening portion which is provided in the circumferential surface of the cylinder-side one end portion and which is in communication with the inside of the cylinder member and the prevention mechanism provided on the inner circumferential surface of the cylinder-side one end portion, the production method further comprising a process of inserting and temporarily connecting one of the parts into the cylinder member wherein the one end portion slides on the cylinder member via the opening portion in the diametrical direction of the cylinder member and is thereby inserted into the cylinder member so that the held portion is provided between the end face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member and so that the rotation of the inserted one end portion relative to the cylinder member around the axis of the cylinder member is prevented by the prevention mechanism.

15. The production method for the transmitting unit according to claim 14, further comprising a connection process wherein the other end portion is rotated around the axis of the cylinder member and then further inserted into the cylinder member so that a width W4 which is the distance between the end face of the other end portion and the cylinder-side protrusion portion is reduced and so that the held portion is held between the end face of the other end portion and the cylinder-side protrusion portion in the axial direction of the cylinder member.

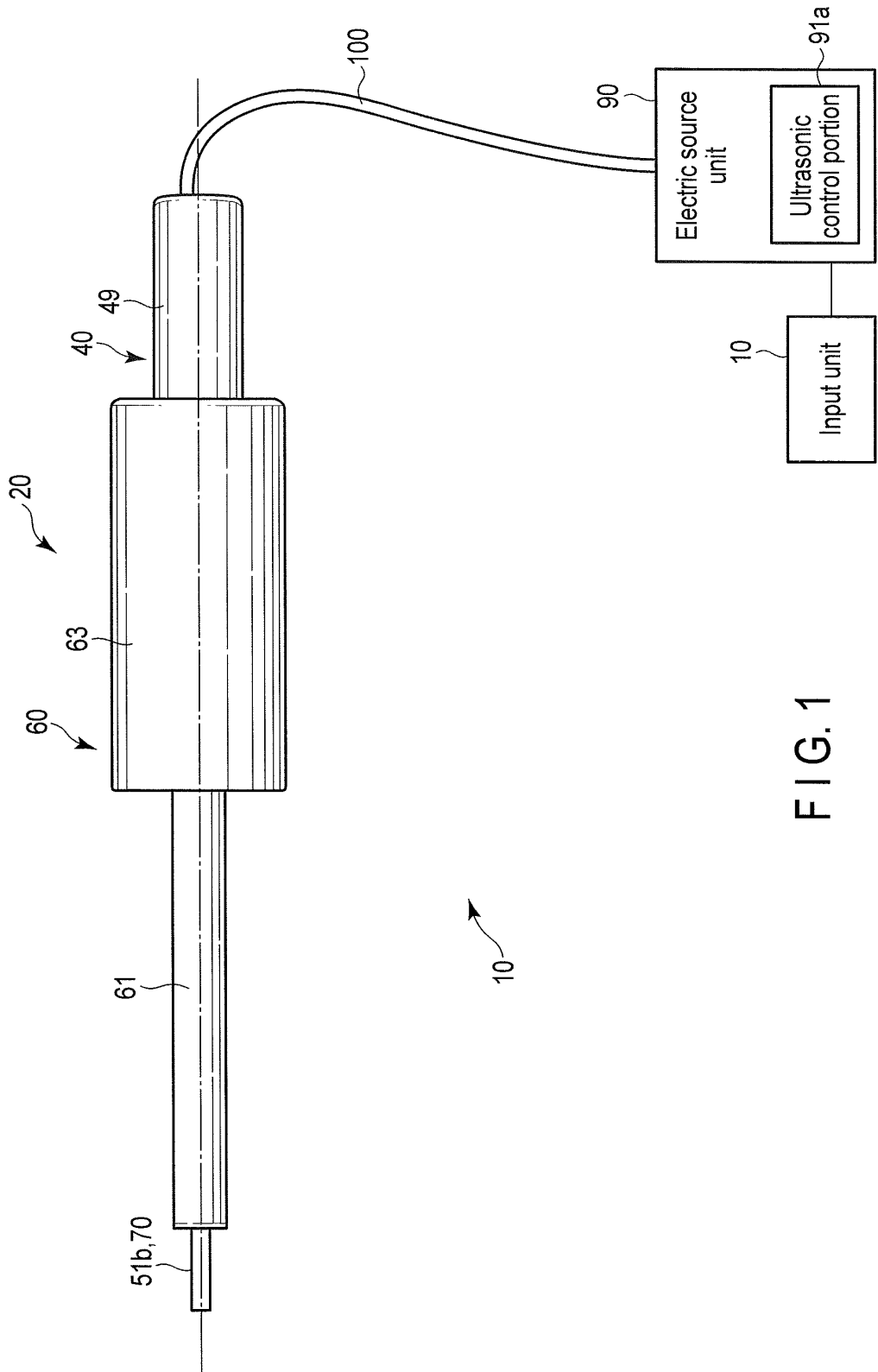


FIG. 1

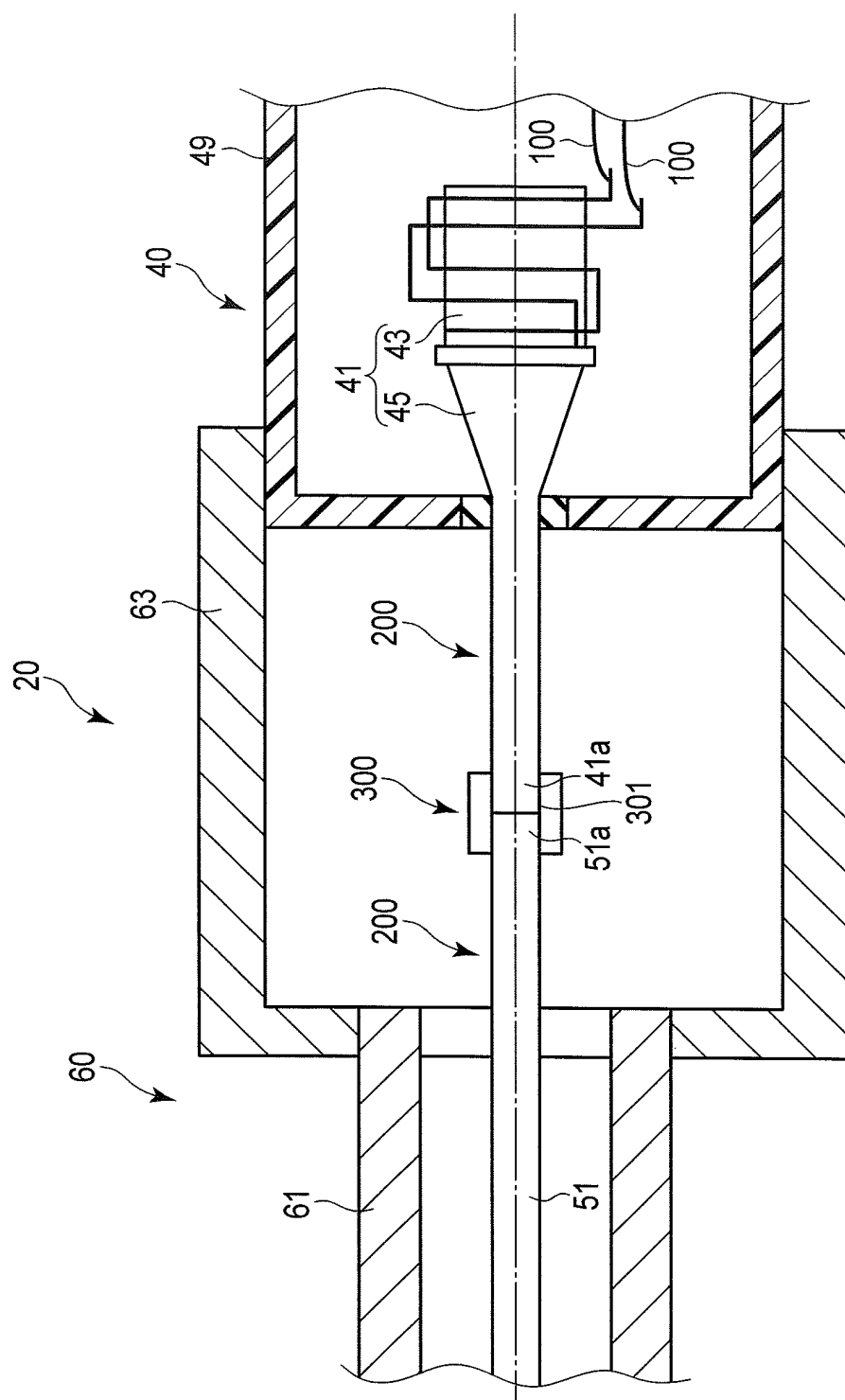
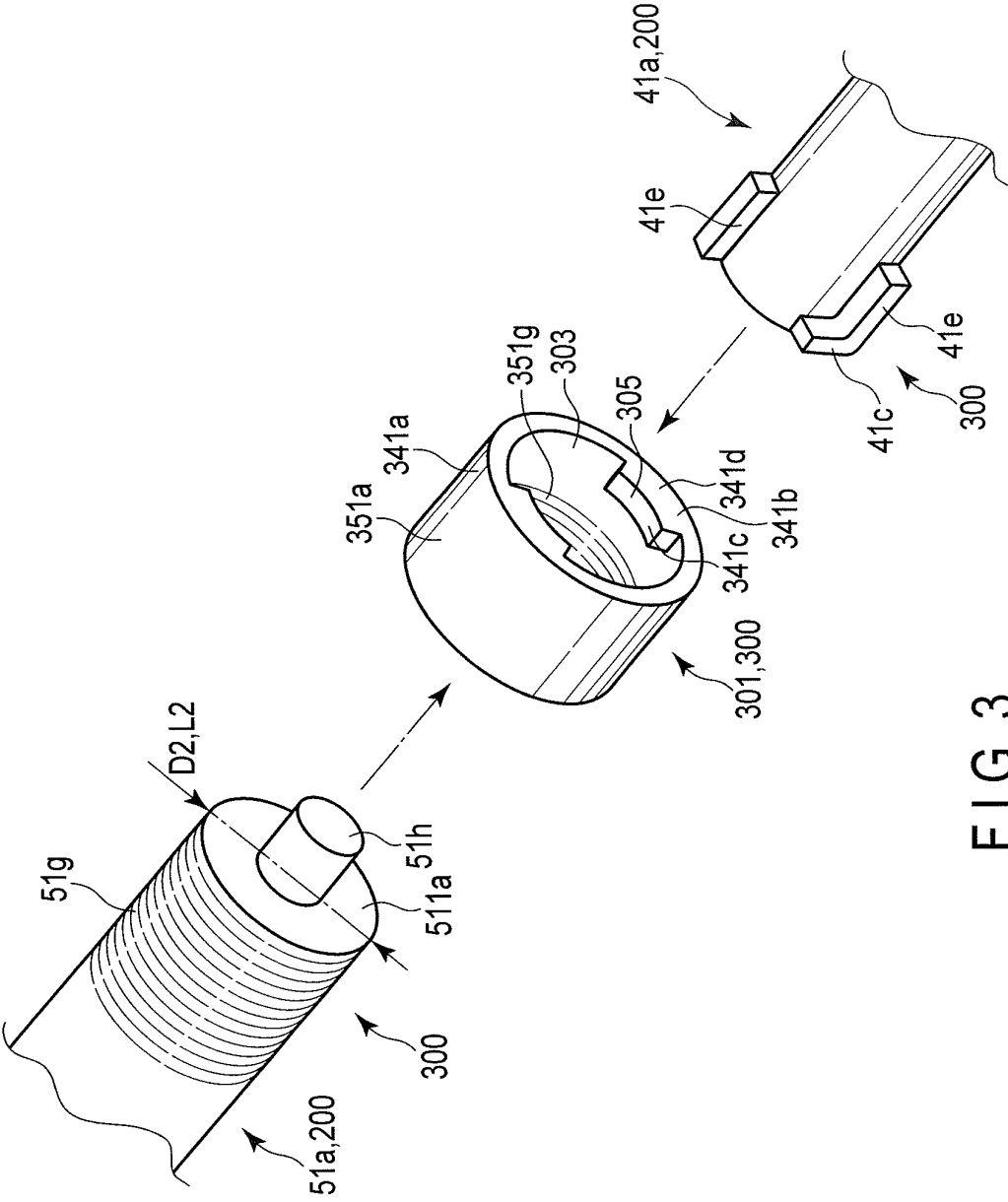


FIG. 2



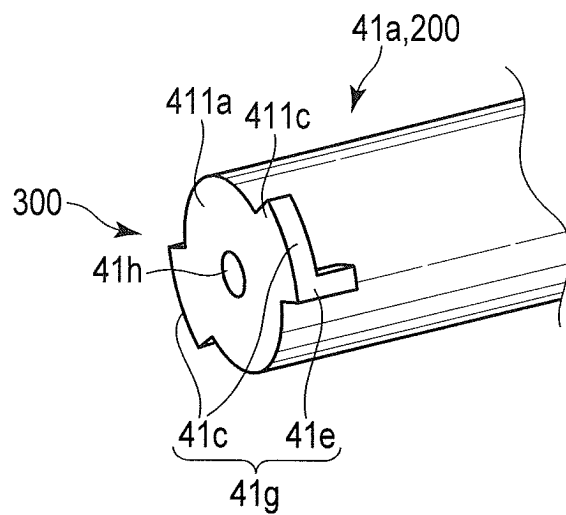


FIG. 4A

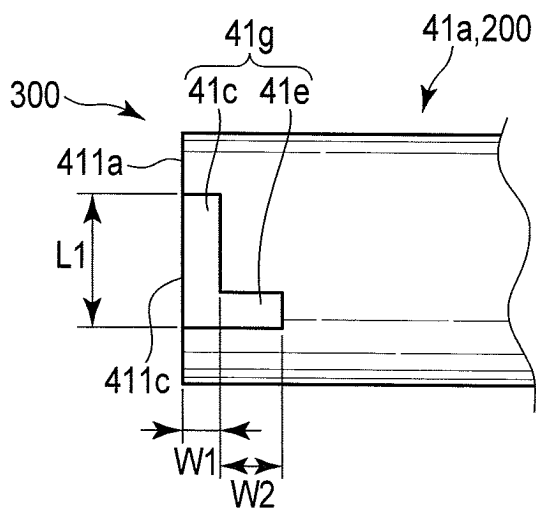


FIG. 4B

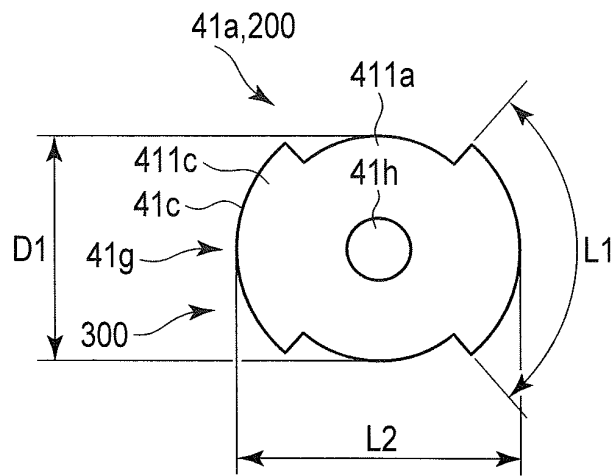


FIG. 4C

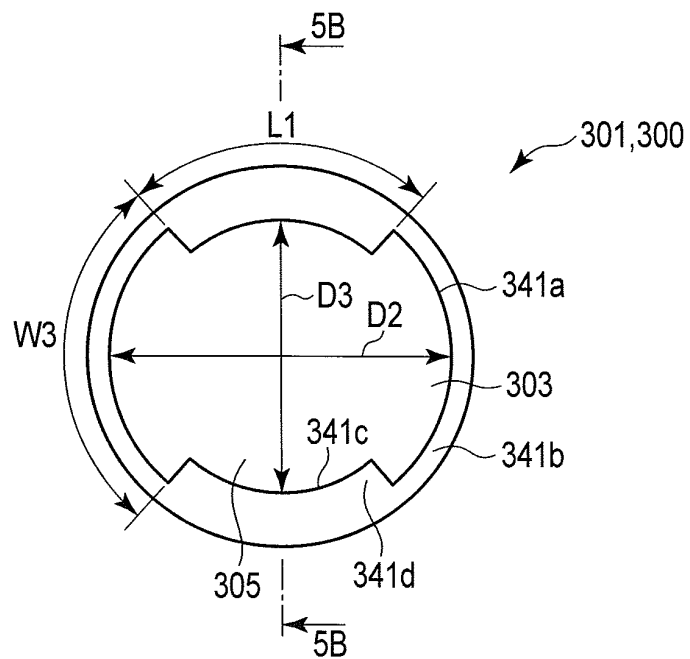


FIG. 5A

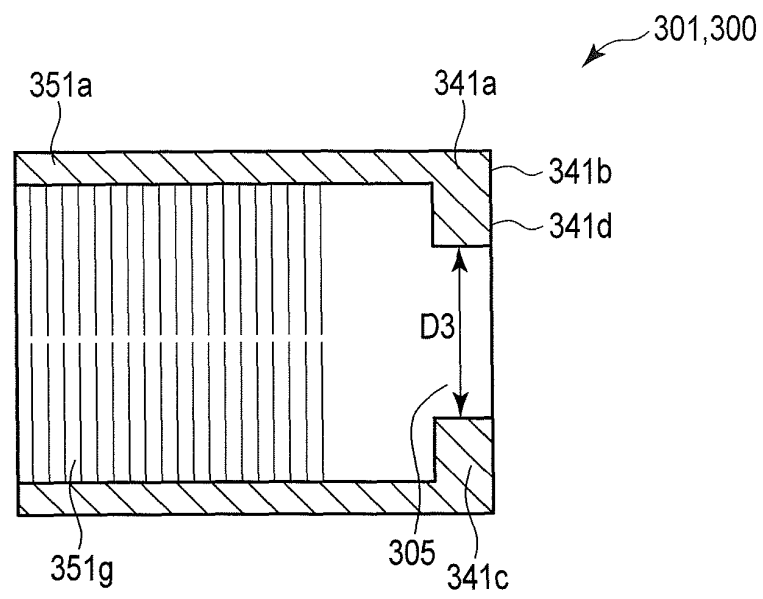


FIG. 5B

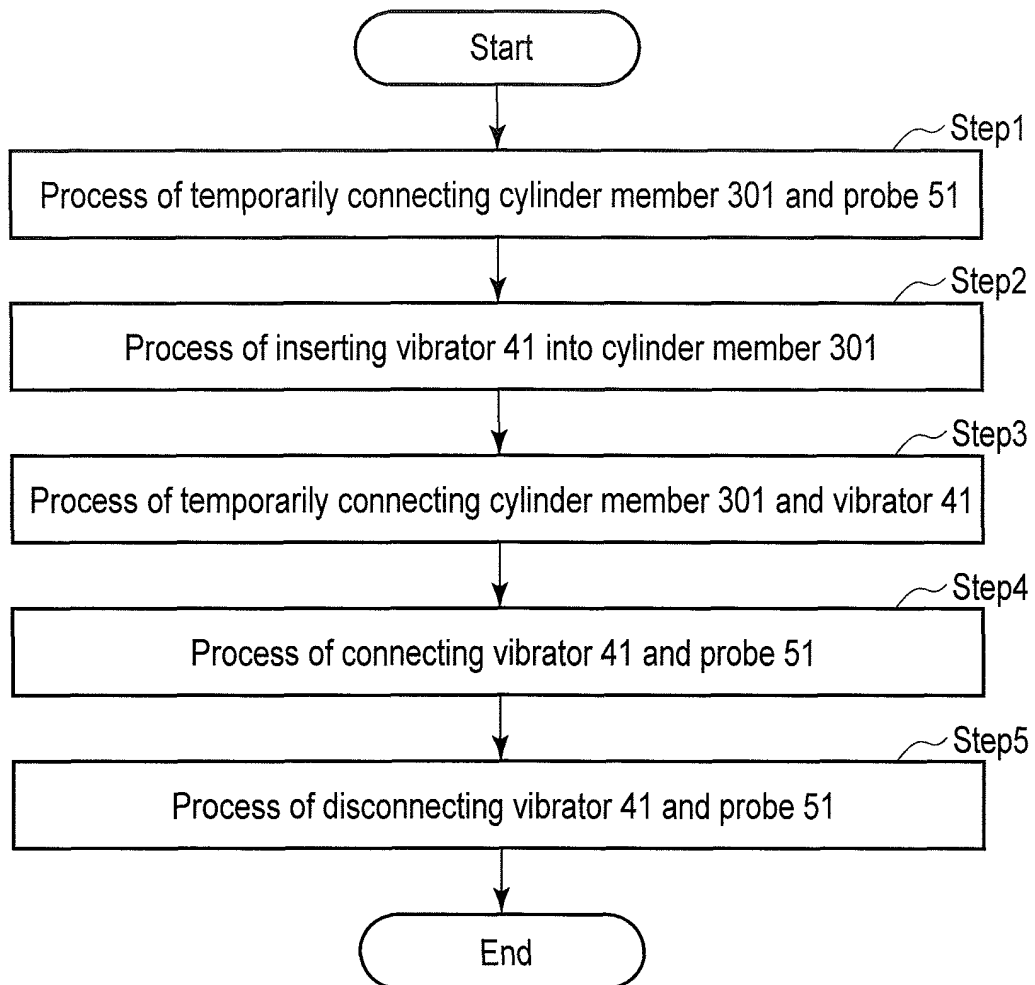
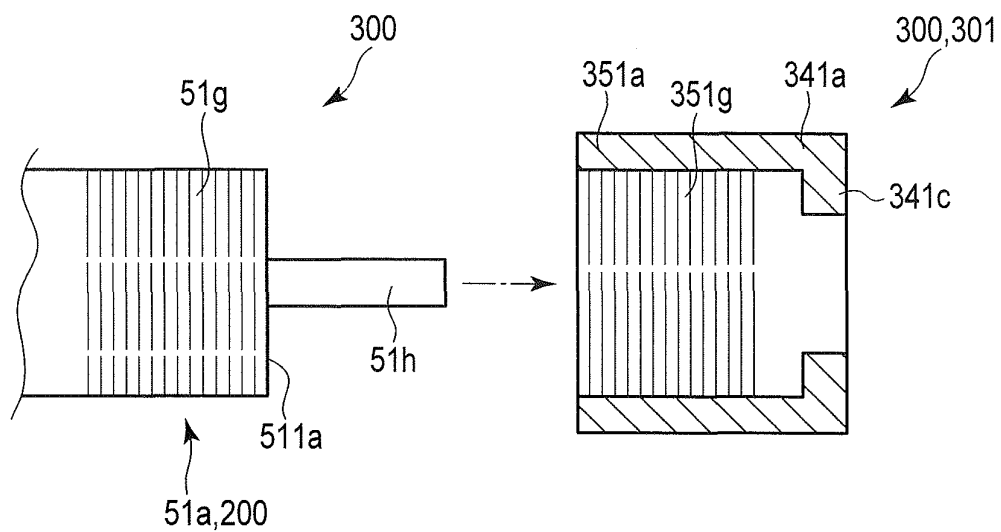
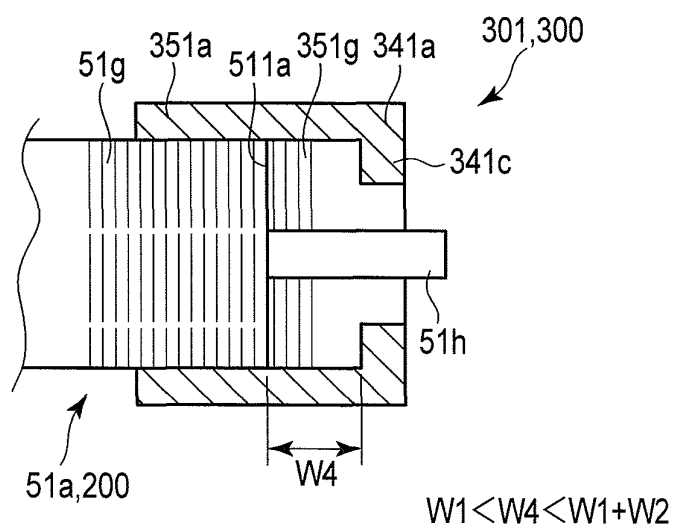


FIG. 6



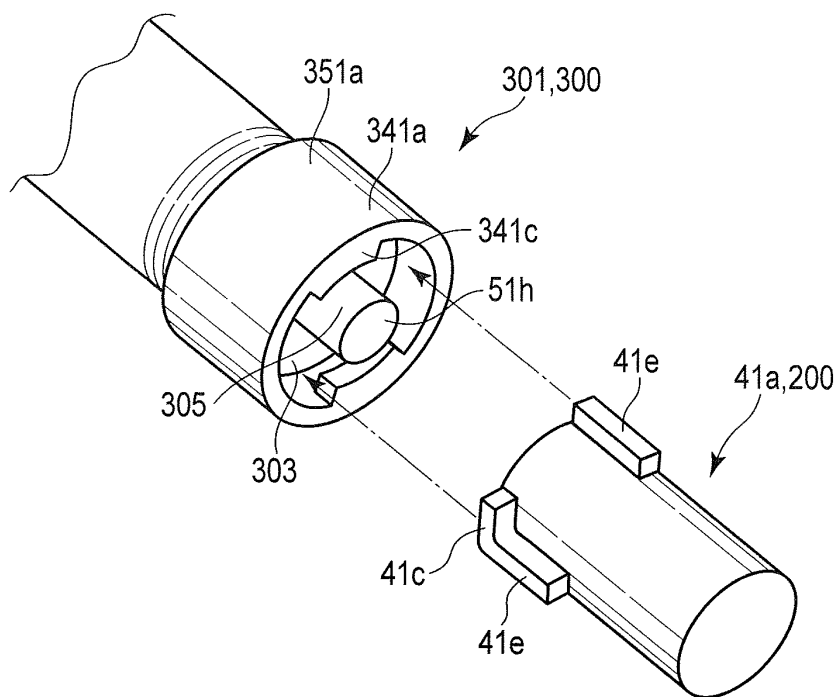
Step1

FIG. 7A



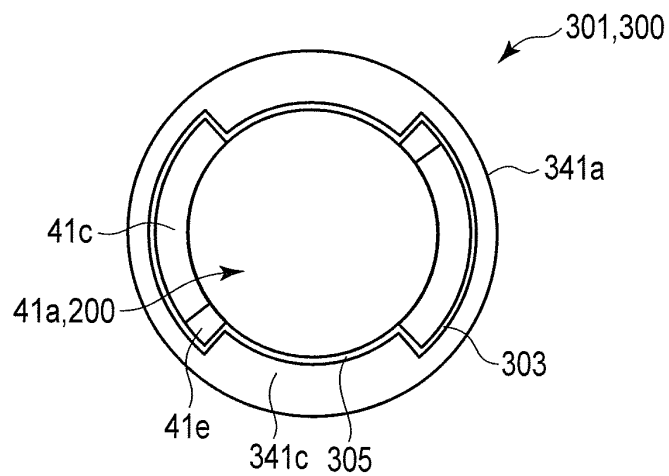
Step1

FIG. 7B



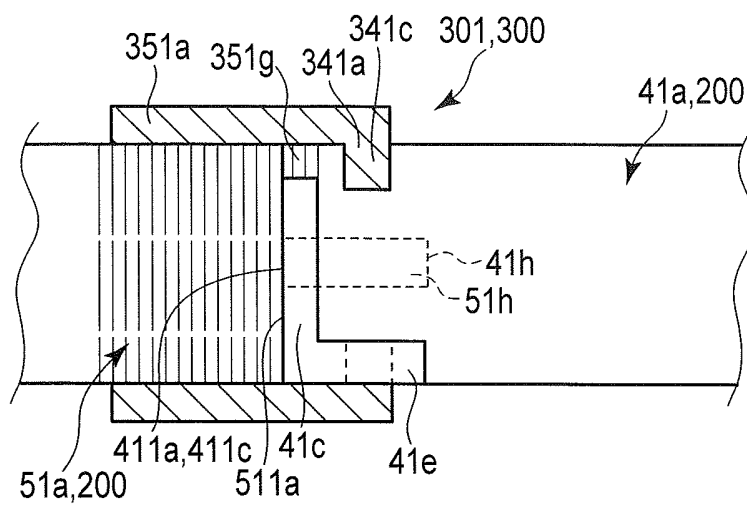
Step2

FIG. 7C



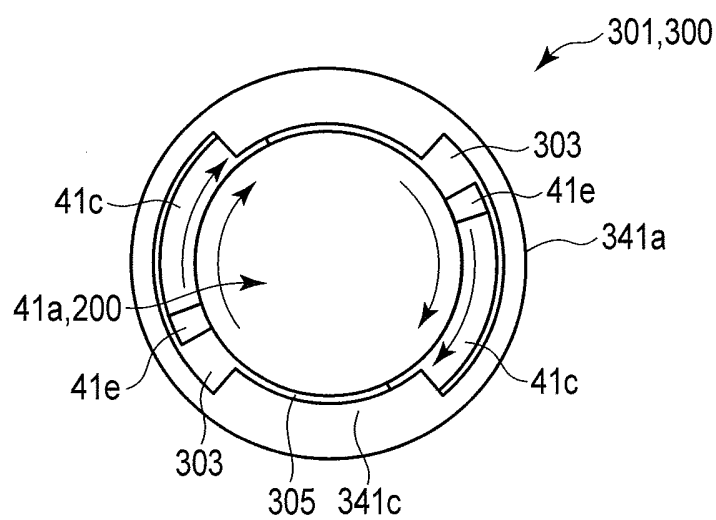
Step2

FIG. 7D



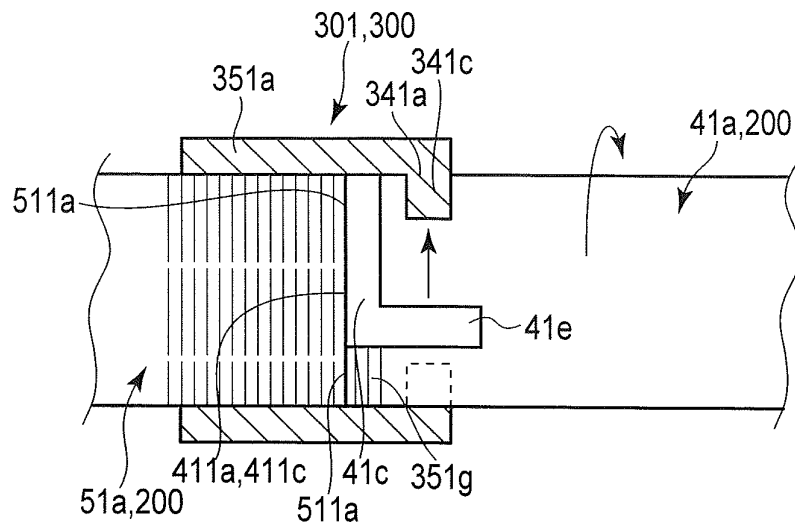
Step2

FIG. 7E



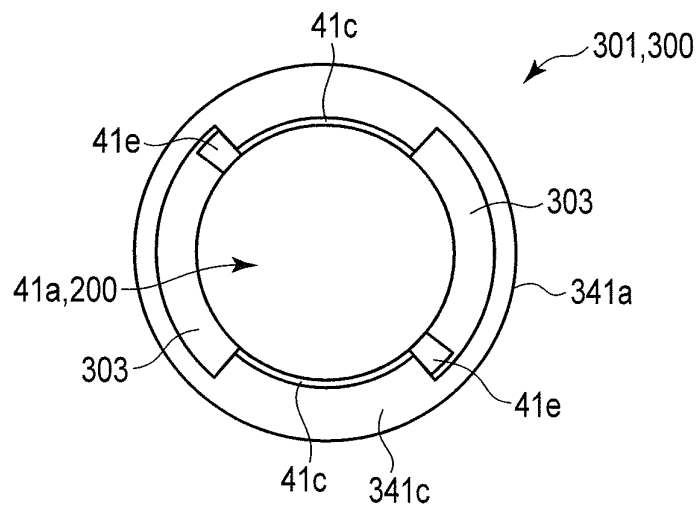
Step3

FIG. 7F



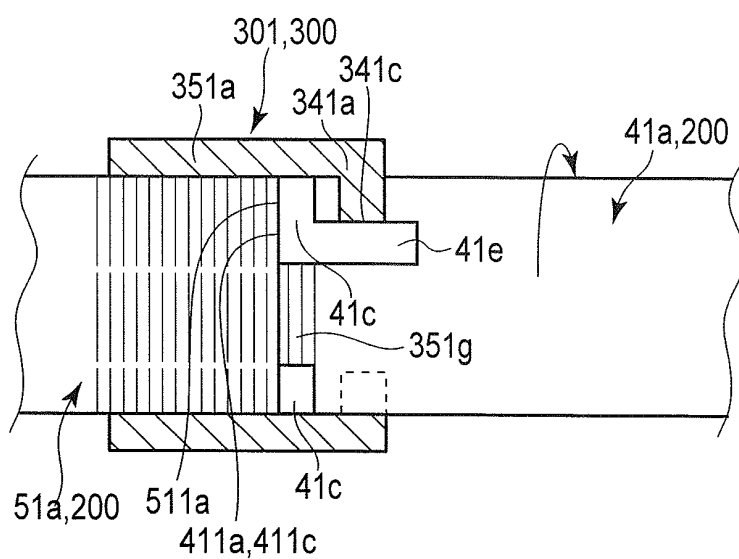
Step3

FIG. 7G



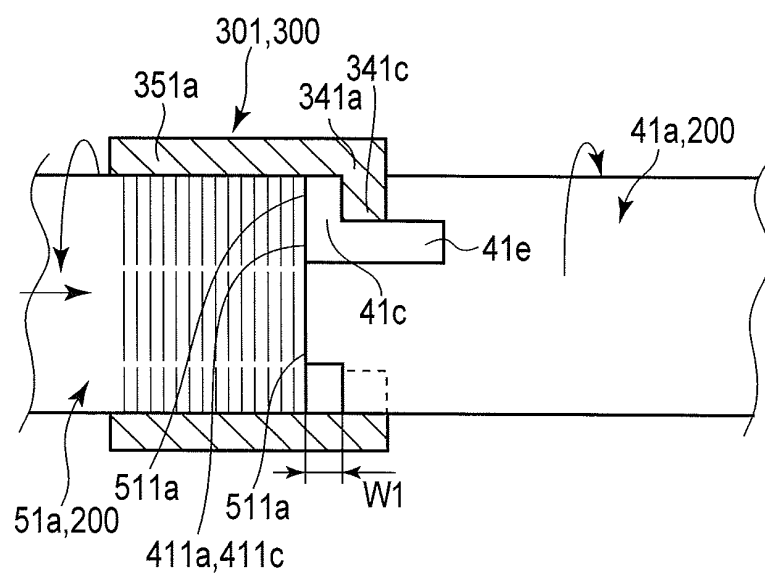
Step3

FIG. 7H



Step3

FIG. 71



Step4

FIG. 7J

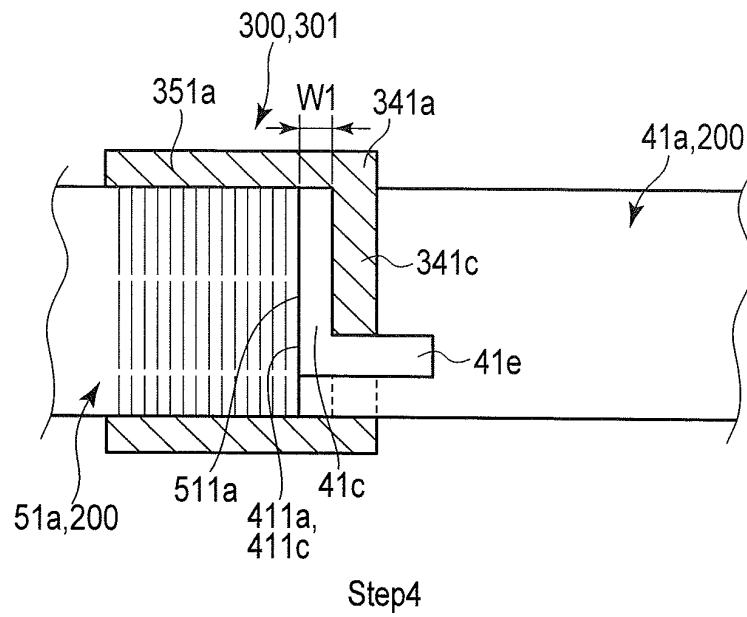


FIG. 7K

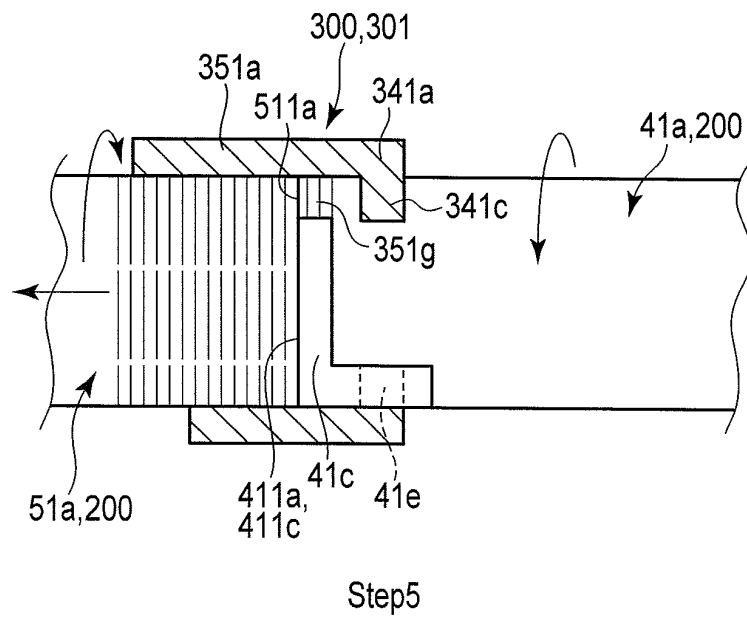
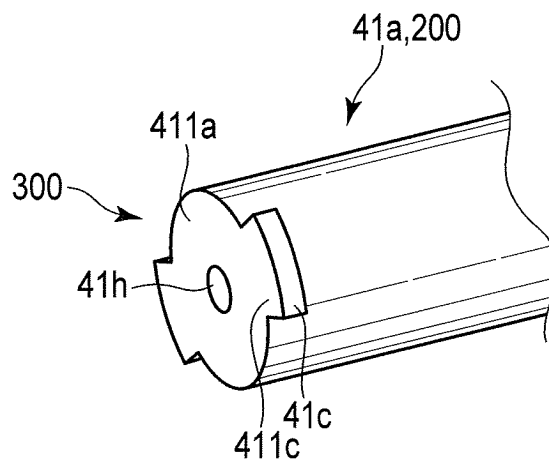
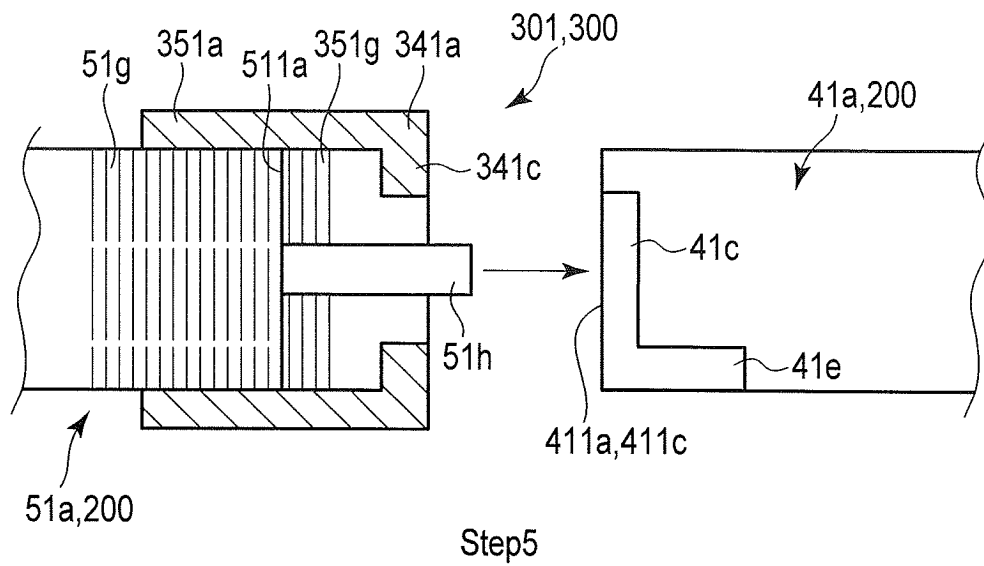


FIG. 7L



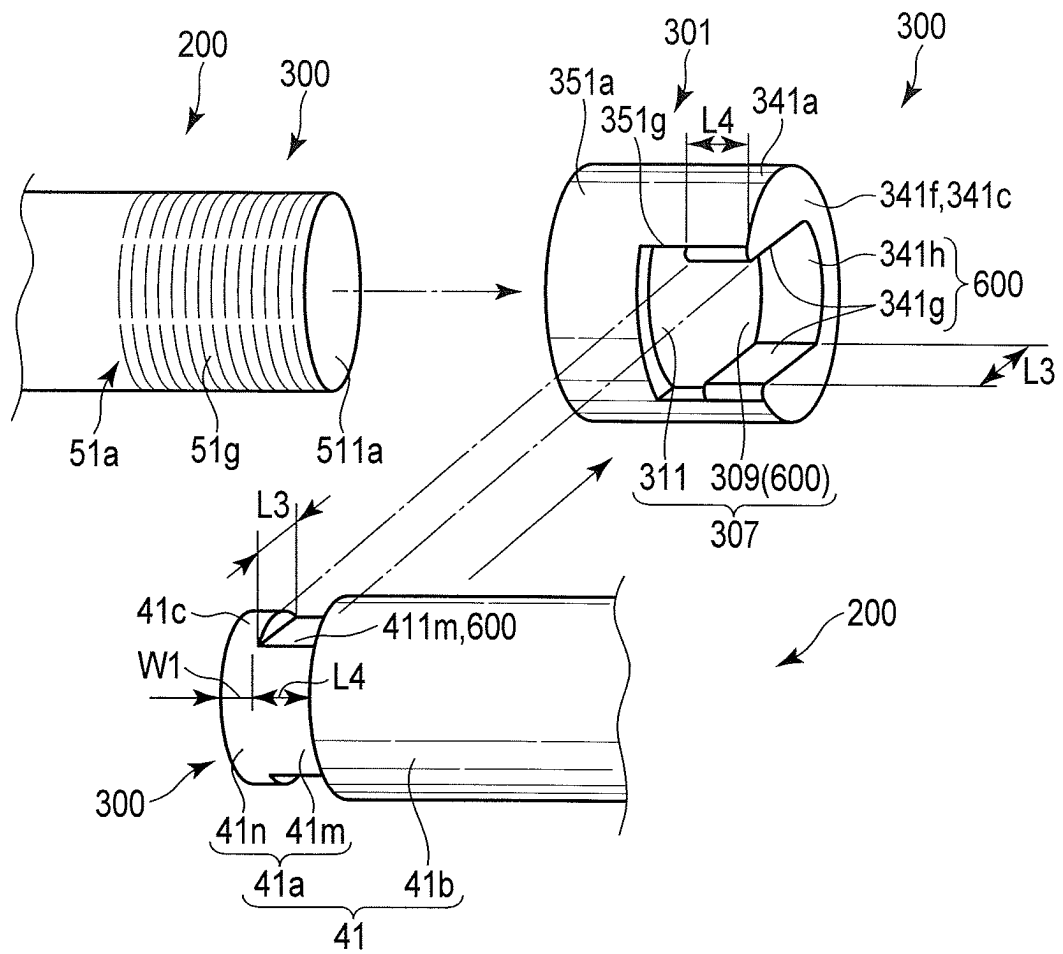


FIG. 9

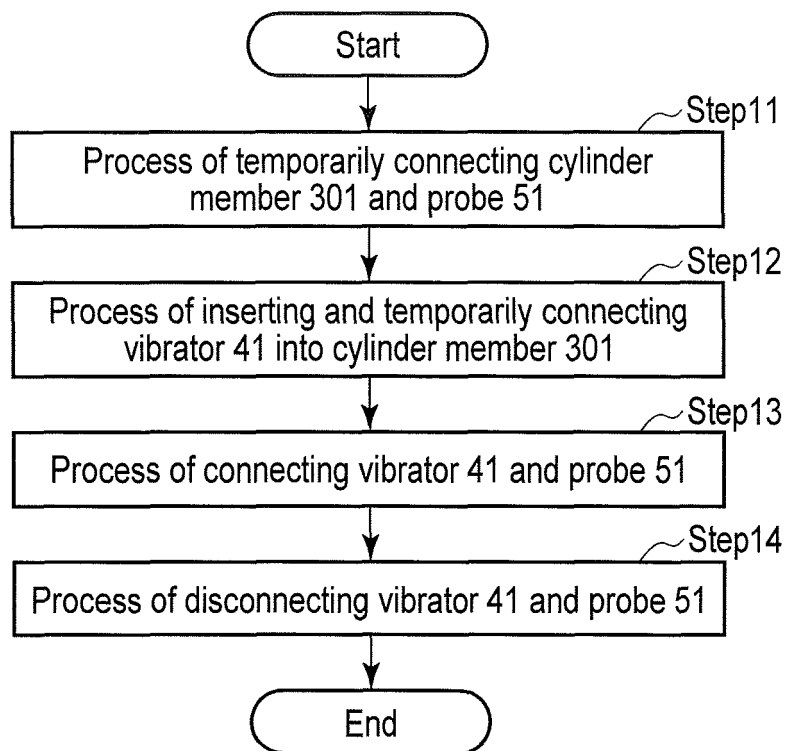
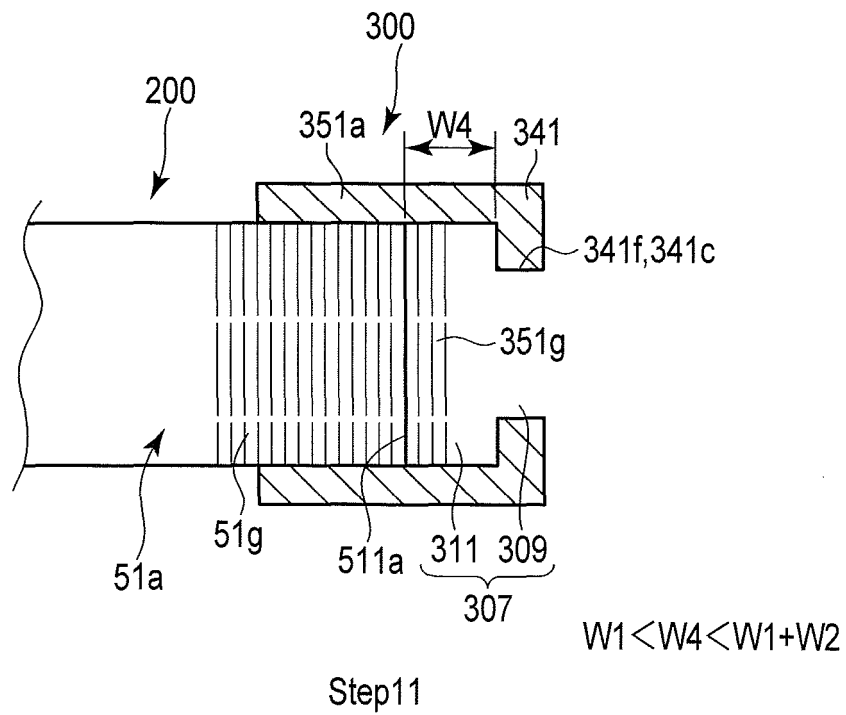
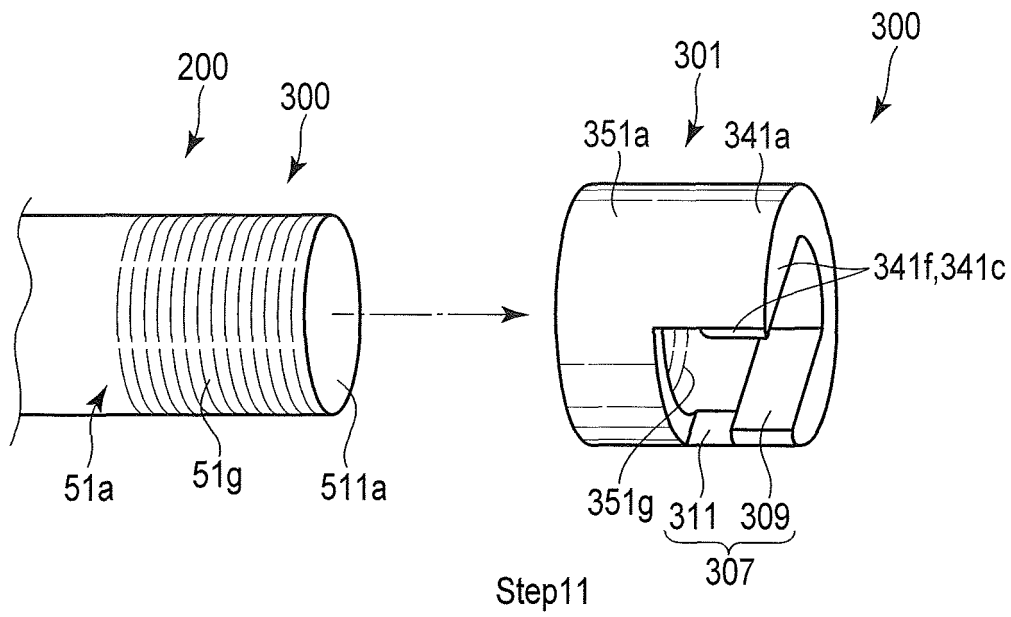
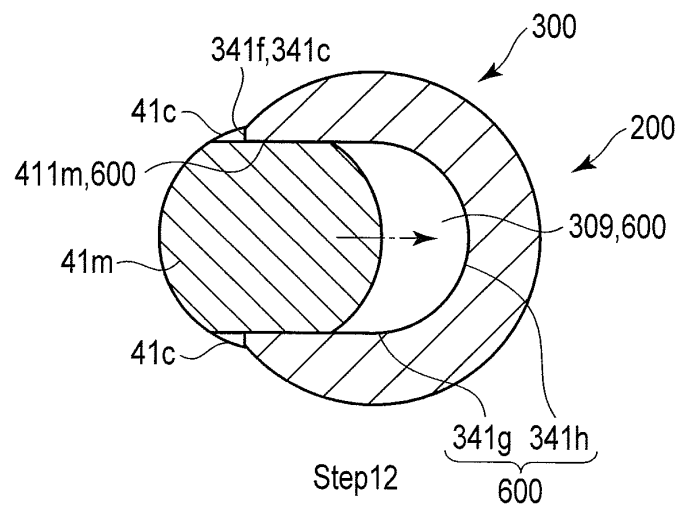
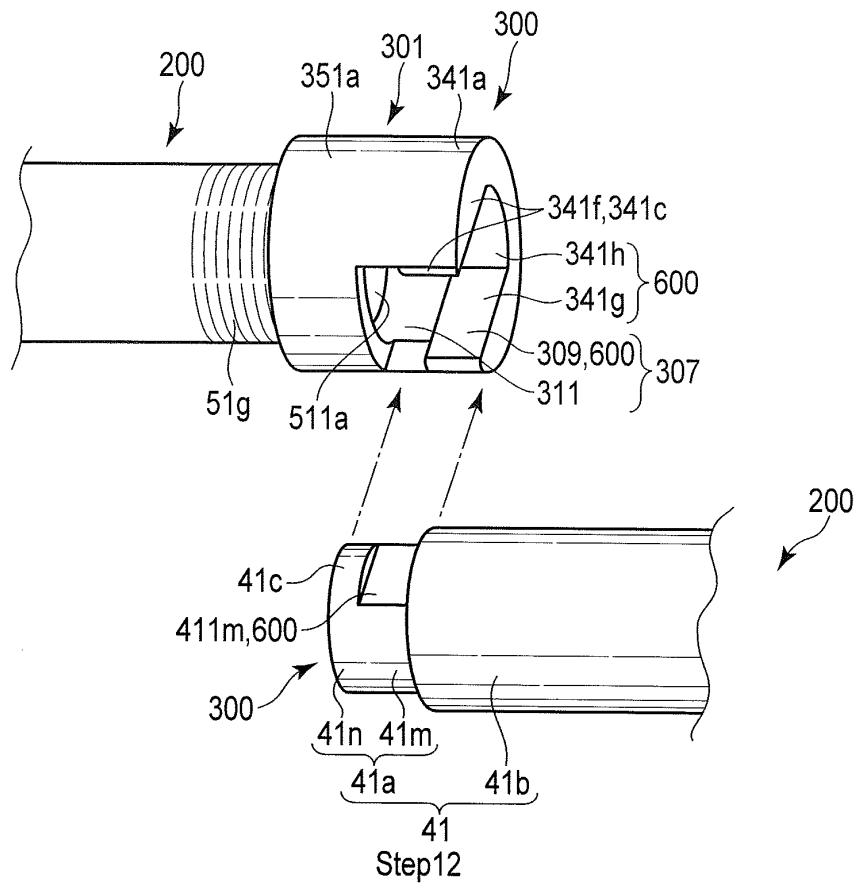
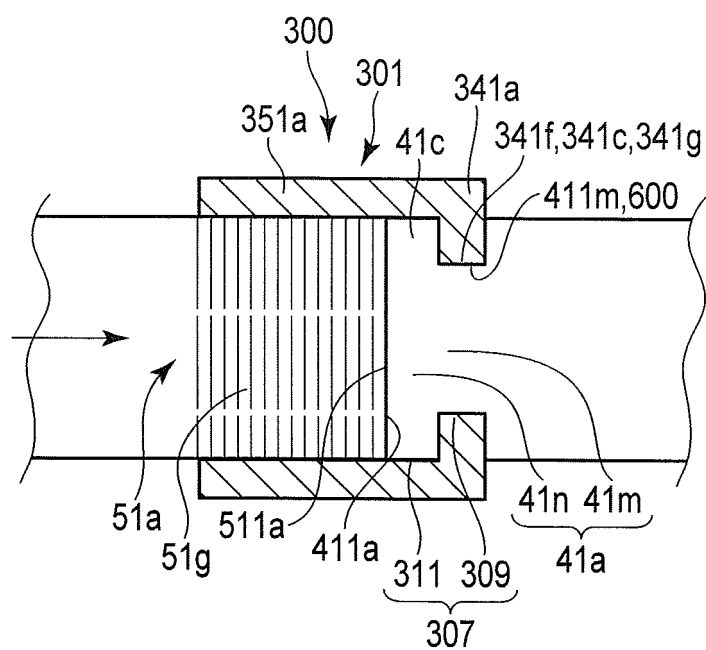


FIG. 10







Step13

FIG. 11E

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/065715

A. CLASSIFICATION OF SUBJECT MATTER

A61B18/00(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B18/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2010-34817 A (NGK Spark Plug Co., Ltd.), 12 February 2010 (12.02.2010), paragraphs [0014] to [0016], [0054] to [0059]; fig. 1 to 3, 10 (Family: none)	1-2, 9-10 3-8, 11-15
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 184627/1982 (Laid-open No. 87810/1984) (NGK Spark Plug Co., Ltd.), 14 June 1984 (14.06.1984), entire text; all drawings (Family: none)	1-15

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
12 August, 2013 (12.08.13)Date of mailing of the international search report
20 August, 2013 (20.08.13)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/065715

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6204592 B1 (HUR, Ben), 20 March 2001 (20.03.2001), entire text; all drawings (Family: none)	1-15
A	JP 8-224252 A (Sumitomo Bakelite Co., Ltd.), 03 September 1996 (03.09.1996), entire text; all drawings (Family: none)	1-15

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 8224252 A [0007]